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AND

POLYTECHNIC SOCIETY

OF THE

WEST RIDING OF YORKSHIRE.

1849—59.

VOLUME III.

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PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-EIGHTH MEETING, HELD IN THE MUSIC SALOON,
WAKEFIELD, ON THURSDAY, MARCH 8TH, 1849.

The Rev. THEOPHILUS BARNES, M.A., Rector of Castleford, Vice-President, in the Chair.

The CHAIRMAN having briefly addressed the meeting upon the subjects about to be brought before them, proposed that

W. W. HEWITSON, Esq., of Leeds, and
WILLIAM HASTINGS, Esq., of Huddersfield,

should be elected Members of the Society.

The first Paper upon the list for this meeting was—

ON THE FOSSIL FLORA OF THE CARBONIFEROUS EPOCH, WITH ESPECIAL REFERENCE TO THE YORKSHIRE COAL FIELD. BY MR. HENRY DENNY, A.L.S.

On a former occasion I had the honour of submitting to this Society a paper "On the Fossil Animal Exuviæ of the Yorkshire Coal Field." It is now my intention, in like manner, to attempt a synopsis of the Fossil Flora of the same locality, derived principally from the specimens deposited in the valuable collections of Coal plants belonging to this Society, and that of the Leeds Philosophical and Literary Society. In turning my attention to this inquiry, however, I have been led to take a glance at the Carboniferous Flora generally, as illustrated by the existing vegetation of the globe, as well as at some of the principal coal-fields of this country, more especially the Lancashire, Newcastle and Durham, and Colebrook Dale, to see whether any, and what, similarity existed between these and the Yorkshire; and also, if any between them and the coal-fields of distant lands. For as the quality of coals from different districts varies considerably, we should be prepared to expect a slight diversity in the plants that have contributed to the formation of each; which is actually the case to a limited extent, as may be seen by comparing in a superficial manner the number of species of plants found in each of the above-mentioned coal-fields, all of which are supposed to be fragments only of one continuous series—the great northern coal-field. Upon this subject I shall not venture an opinion, it being no part of my object to prove the identity of these three great deposits, but rather to endeavour to show that there is not only a slight diversity in the fossils of each locality, but also in the *individual seams* of one coal-field; for upon no other grounds, it has long appeared to me, could we account for the very different quality of the coals worked at Barnsley, Lofthouse, Rothwell Haigh, Manston, Churwell, Middleton, and Halifax, in this district; as also in certain seams of superior quality which occur in the Lancashire and Newcastle coal measures. And reasoning from analogy, as we know that sugar, gum, and starch, though apparently so different in qualities and properties, are all primarily derived from the same elementary constituents, under slightly different proportions or arrangements; and as we also know that plants yielding such an innumerable diversity of substances in their recent state, are yet all resolvable into carbon, oxygen, hydrogen, and nitrogen, why may not coals primarily derived from vegetable reliquiæ, yet possess varied degrees of inflammability, &c., from the greater or lesser proportion they contain of such plants as yield the largest amount of combustible matter. This supposition, I much regret, it has not been in my power to verify from actual examination of all the coals just enumerated. In the Middleton coal, which has come more immediately under my observation, I have recognized Stigmaria, Favularia, and Lepidodendron; and in the museum of this society are several very perfect examples of Favularia in solid coal whose locality is not recorded. This point, however, which I have thus been unable to accomplish for our own district, has, I rejoice to find, been most ably and conclusively demonstrated by the researches of Professor Goeppert, of Breslau, in the coal-fields of Upper and Lower Silesia, from whence four millions of tons are annually raised. Here he met with extensive layers or seams of coal, in which were plants so well preserved, of Sigillaria, Stigmaria, Calamites, Lepidodendron, and Noggerathia; and that, according to the predominance of one or the other genus of plants, he could distinguish in many places coal of Sigillaria from Araucarian or Lepidodendron coal, of which the last was the rarest.* Subsequently he examined the coal strata of Saarbruck, near Aix-la-Chapelle, in Liege, and in Westphalia, and in each locality found exactly as in Silesia, though not in such perfection, that the coal itself contained plants visible with the naked eye; and in addition to those mentioned above, in a pit at Norheim, near Kreuznach, for the first time, a fern, Cyatheites arborescens, together with so many Calamites belonging to the species known as Calamites decoratus, that he thought himself justified in designating it Calamite coal.†

From his investigation of the Flora of the brown coal formation also, it appears that this is almost solely derived from Coniferous plants. Out of 300 specimens of bituminous wood, collected in the Silesian brown coal deposits alone, scarcely any other kinds occur besides the wood and fruit of a Taxus and Cupressinea. In other districts, the Pinites protolarix occurs. The number of species of Coniferiæ, however, upon the whole, is very small in comparison with the enormous mass of brown coal they have contributed to form, from which he infers that the Coniferiæ of the ancient world had a similar gregarious mode of growth with those that now flourish on the earth.* Similar facts appear to have been noticed by the venerable Humboldt, who observes in his last work, "Where several series of coal strata lie over one another, the genera and species are not always mixed; they are rather, and for the major part, generically arranged so that only Lycopodites and certain ferns occur in one series of beds, and Stigmaria and Sigillaria in another."†

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* Report of the British Association, 1846, p. 50.

† Quarterly Journal of the Geological Society, vol. v., p. 17.

Although the Newcastle coal-field does not appear to have afforded any positive evidence upon this point to the authors of the Fossil Flora, they nevertheless inferred the fact, as will be seen by the conclusions at which they arrived. After stating that there are three principal varieties of coal in the Northern coal-field—the Fine caking Coal, the Cannel splint or Parrot Coal, and the Slate Coal, which in some instances occur in the same seam or bed, where they are not indiscriminately mixed, but have a well-defined line of separation, they observe, "It is certain each bed of coal, and more particularly each separate layer in that bed, must have been placed in precisely similar circumstances since the deposition of the vegetable matter of which it is composed; and we cannot suppose that matter to have obtained any of its elements after it was buried in the earth, but rather that the difference between the several varieties of coal arise from some difference existing previous to deposition, and that difference is most likely to have been originally in the nature of the plants of whose remains the coal beds consist."*

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* Quarterly Journal of the Geological Society, vol. v., pt. ii., p. 6.

† Kosmos, vol. 1, p. 299.

Having proved this point, our next one for consideration is that of the geographical distribution of species; for there is one circumstance observable in the flora of the carboniferous period which is very remarkable, as apparently indicating an universality of vegetation, or that in former ages the range of the species of plants was far more extensive than at the present day. Dr. Hooker observes, "It appears that an uniformity once existed in the vegetation throughout the extra tropical countries of the northern hemisphere, to which there is now no parallel; and this was so, whether we consider the coal plants as representing all the flora of the period, or a part only, consisting of some widely distributed forms that characterised certain local conditions." If we compare the floras of modern Europe and America we find them essentially unlike, while if we examine the floras of the coal fields of these two distant regions, we are instantly struck with the remarkable fact, that not only nearly all the genera, but many of the species, are precisely the same. Even in Melville Island, deep in the Arctic regions, plants, identical with those in the coal formation of Britain, are said to have been found. Sir C. Lyell, in describing the coal-fields of Nova Scotia and Cape Breton, says, "Out of forty-eight species, without enumerating the different varieties of Stigmaria, there are no less than thirty-seven which have been identified, of which twenty-two are identical with British coal plants; four or five may be considered as varieties of British types; and two appear to be identified with European species not yet discovered in Britain; and the greater part of the remaining eleven might, perhaps, have been found to agree with well known fossils, had not most of the specimens been too imperfect to admit of a close comparison."* Again, out of twenty genera of coal plants from Australia, thirteen are common to the coal-fields of Britain, and six are well known in the Oolitic coal deposits of Yorkshire.

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* Fossil Flora, vol. ii., pp. 25, 26.

How near these appearances may approximate to, or what was the actual state of, the flora at such distant epochs, it is impossible now to tell, and as unwise to theorise from, as it is to argue, that because we have Cycadean plants and Tree Ferns embedded in our strata, we must have had, in remote ages, a tropical climate; such inferences, however, are perfectly gratuitous, as founded upon inaccurate observation. For as Dr. Lindley remarks, "That, as many of these supposed tropical plants are in reality destitute of living analogies, and, therefore, as we do not know what they were, we have no means of judging what kind of climate they required. Supposing, however, that some of the Lepidodendra were allied to the genus Araucaria, yet that fact does not afford any proof of a tropical climate; for Araucaria Dombeyi now inhabits the cold mountains of Southern Chili, and is at this day uninjured in the severest of our English winters; while Cunninghamia sinensis, and species of Callitris or Dacrydium, with which other remains of Lepidodendra may be compared, are found on the mountains of New Zealand and Van Diemen's Land, where they have anything but a temperate climate; and Salisburia Adiantifolia, which would certainly be considered a tropical form of Coniferiæ if found in a fossil state only, is one of the hardiest of trees, and a native of the rigorous climate of Japan. The supposed succulent nature of such plants as Sigillaria, Favularia, &c., which would ally them to the Cactaceæ and Euphorbiaceæ, although the majority of such plants are natives of hot countries, would afford no real evidence that a tropical climate was essential to their development. Houseleek and many other hardy plants are equally as succulent as the Cactaceæ; and neither palms nor tree ferns are exclusively tropical, though abounding at the present day in such countries. We may adduce the Date palm, Phœnix dactylifera, which is cultivated in Sicily, and even at Bordighiera, in Liguria; the Palmetto, Chamærops humilis, found as far north as Nice; the New Zealand Areca, which is seen in many places where the ground is sometimes covered with snow for several days; or the Palma Magellanica, which, according to Humboldt, has been seen in 53° S. latitude; and the gigantic wax palm of the Andes, Ceroxylon, which rears its lofty head in climates too inhospitable for any other palm, among the snow-clad summits of Tolima, San Juan, and Quindiu, at an elevation of 8,700 feet, 6,000 feet higher than palms are usually met with. And as for Tree Ferns, which are of rare occurrence in a fossil state, we find them in New Zealand, and on the South side of Van Diemen's Land, where the mean temperature little exceeds 54° of Fahrenheit. So that, from these instances, we have sufficient proof that no evidence of a satisfactory character can be derived from the fossil flora, indicating a tropical climate, or one materially differing from that of the present day."* If, indeed, any theory is strengthened by the facts which fossil botany presents, it is that of equability of temperature. The excess of watery surface, which it is demonstrable at one time existed, would very much tend to equalise the temperature of the islands, which, it is presumed, were emerging from the bosom of the deep. And, although the evidence is not yet complete, the theory of more equable temperature receives some confirmation from what has been already adduced;—that the coal floras not only of North America and Europe are for the most part identical, but also that of the few fossil plants from Baffin's Bay, New Holland, and Hindoostan (from the northern, the southern, and the torrid zones), the chief are genera belonging to the same natural groups with those which predominate in the coal formations of central Europe; and this uniformity of vegetation is one strong evidence of uniformity of temperature, as well as of other physical conditions.

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* Travels in North America, vol. ii., p. 158.

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* Penny Cyclopædia, vol. vii., p. 295.

With respect to the Ferns, however, which of all fossil plants can alone be referred with certainty to their proper place in the vegetable kingdom, and in a recent state have, of all plants, the widest geographical distribution, a glance, for a few moments, at the range of a few of the existing species, may throw some light on the fact before alluded to,—of the identity of species in the fossil floras of Europe, America, and Australia, and which appear less extraordinary if we observe the large proportion of ferns in the ancient vegetation, and their distribution at the present day. Thus of forty-two ferns found in the North of Italy, thirty-four are also British. Iceland has fourteen ferns, all of which are British, and all, but one, found in Italy. Of twenty-six ferns enumerated as natives of Greece, twenty-one are British, and eight common to Greece and Iceland. One-third of the ferns of Madeira—twelve out of thirty-six, are British; two species, Polypodium vulgare and Cystopteris fragilis, are common to Madeira and Iceland, a greater latitude than any fossil fern has yet been found to possess. Sixteen out of twenty-eight ferns of the Azores are British. When we cross the Atlantic a greater difference is observable. Out of sixty-nine ferns of North America only thirteen are European species. It is also assumed that within the tropics ferns have a very wide range, as, for instance, from the West Indies to Rio de Janeiro. Still, however, if we take the uniformity of vegetation as testified by the ancient flora extending over so large an area as from Scotland to

Alabama in latitude, and in longitude from Bohemia to the Ohio, we can find no parallel to it in the existing flora of the globe. Connected with this subject is the numerical proportion which ferns are supposed to have borne to the Phænogamous vegetation, at the period of the deposition of the coal strata, as compared with their proportion at the present day. Dr. Lindley says, "Two-thirds of the species of plants which have been detected in this formation are ferns. The earliest flora of the globe was composed of ferns, almost to the exclusion of other plants." Burnet observes, "The relative predominance of ferns seems to have been greater in the coal era than at any other period; from present data they appear to have then formed more than three-fifths of the vegetation of the earth." Goeppert states that out of 1,792 species of fossil plants known, upwards of 524 are ferns. I cannot, however, help thinking that too much weight is given to the proportion they now bear in a fossil state, since the experiments of Dr. Lindley, to which I shall shortly allude, clearly demonstrate that above two-thirds of the vegetation of the present day are not capable of resisting submersion in water for two years, and, consequently, if submerged now, would leave no relics for after ages to decypher. This fact, however, while it teaches us the necessity of extreme caution in assuming the non-existence of species, because they have left no remains, does not invalidate the assumption that ferns greatly preponderated in remote ages of the world; as an approach to this disproportion between ferns and the rest of the flora is even now exhibited in certain tropical islands, such as Jamaica, where they form $\frac{1}{9}$ of the Phænogamous plants; New Guinea, where they are as 28 to 122; New Ireland, where they are as 13 to 60; and in the Sandwich Islands, as 40 to 160. Upon Continents, however, they are far less numerous. Thus in Equinoctial

America, Humboldt estimates them as $\frac{1}{36}$; and in New Holland as $\frac{1}{37}$. They decrease again in proportion as we approach towards either pole, so that in France they are only $\frac{1}{63}$, in Portugal $\frac{1}{116}$, in the Greek Archipelego $\frac{1}{227}$, and in Egypt $\frac{1}{971}$. Northward of these countries their proportion again augments, so that they form $\frac{1}{31}$ of the Phænogamous vegetation of Scotland, $\frac{1}{35}$ in Sweden, $\frac{1}{18}$ in Iceland, $\frac{1}{10}$ in Greenland, and $\frac{1}{7}$ at North Cape. No ferns have yet been discovered in the most northern parts of the arctic zone, as is shown by the catalogues of plants from Melville's Island and Spitzbergen. It appears from the observations of Dr. Hooker that where ferns prevail flowering plants are less abundant, and vice versâ; which he illustrates by a comparison of the vegetation of Tasmania and New Zealand. The former of these islands, barely 250 miles long, contains four times as many species of flowering plants as New Zealand, whose total length is 900 miles. On the other hand, this latter country possesses more than four times as many kinds of fern as Tasmania. In New Zealand he collected 36 species of fern, in an area of only a few acres, which presented scarcely a dozen flowering plants besides; while an equal area in the neighbourhood of Sydney, (in the same latitude) would have yielded upwards of 100 flowering plants, and but two or three ferns.

"The total known number of existing species of ferns at the present day is probably 1,500, whose geographical distribution is about the following:—1. Those of the temperate and frigid zone of the northern hemisphere, about 144 species. 2. Those of the southern temperate zone, including the Cape of Good Hope, parts of South America, and the extra-tropical part of New Holland, and New Zealand, 140 species. 3. Those which grow within 30 or 35 degrees on each side of the Equator, 1,200 species.*"

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* Buckland's Bridgewater Treatise, p. 462.

That the species of plants found in the shales and sandstones of our coal fields are so few, as compared with those now existing, is not remarkable, but rather what we might, *à priori*, expect, if we reason from the aspect which dense primæval forests at the present day exhibit to our view, and from whence we are entitled to borrow a retrospect of the past. For as Playfair observes, "Amid all the revolutions of the globe the economy of nature has been uniform, and her laws are the only things that have resisted the general movement. The rivers and the rocks, the seas and the continents, have changed in all their parts; but the *laws* which direct those changes, and the rules to which they are subject, have remained the same." The idea also which some persons entertain, that, at the period of the deposition of the coal fields, the species of plants existing on the earth were few, and consisted of only such as we now find embedded, no grasses, no flowering plants, and scarcely any dicotyledonus plants, is not borne out by the revelations of geology. That the cereali and various other plants formed the early clothing of the earth is almost certain, though no traces of them exist; but the cause of their disappearance is sufficiently obvious, and to which I shall call your attention.

In the first place, however, I would observe, that in the trackless forests of America the aborigines are generally white or red pine, black, white, or hemlock spruce, maple, beech, birch, and other trees capable of attaining great size, which spring up from a bed of black vegetable mould, and, from their accumulation, choke up and finally destroy other smaller trees. Hence we see that in old forests, trees of the largest growth and longest life have a tendency to prevail to the exclusion of underwood, and the consequent greater increase of mosses, ferns, and lycopodiums, whose growth is accelerated by such humid localities, the graves of departed giants of the vegetable world, whose trunks have mouldered away through successive generations. That such was also the nature of the primæval forests, antecedent to the formation of our coal fields, we can have little doubt, whose vast accumulation of debris on the surface, continually augmenting through long periods of time, would, by their deposition, consolidation, and submersion, contribute materially to form the various seams of coal now again brought to the light of day for the benefit of man. The plants at that epoch, however, being primarily gigantic Sigillariæ, rising to seventy feet in height, Lepidodendra, Ulodendra, Bothrodendra, &c., with an under-growth of Ferns, Calamites, Equisetums, Sphenophyllum, Asterophyllites, &c., hence we conclude, that as at the present day, so it would be in the past, no very large number of different species of plants would grow in the densely wooded parts of the globe, from the causes before stated.* A greater variety would be found, however, in the plains, marshes, and mountain sides, which would make little or no figure in the present flora of the coal strata, from the fact that only a very limited number could bear the long submersion, and yet leave us their remains to the present day. This has been most satisfactorily and clearly demonstrated, in a series of experiments instituted by Professor Lindley, for the express purpose of testing the durability of various genera and species of plants. He says:—" On the 21st of March, 1833, I filled a large iron tank with water, and immersed in it 177 specimens of various plants, belonging to the more remarkable natural orders, taking care, in particular, to include representatives of all those which are either constantly present in the coal measures, or as universally absent. The vessel was placed in the open air, left uncovered and left untouched, with the exception of filling up the water as it evaporated, till the 22nd of April, 1835, that is, rather more than two years. At the end of that time, what remained was examined, when it was found that of the 177 only 56 remained recognisable; 121 were entirely decomposed, and those which resisted were precisely such plants as we now find fossil." From these facts the Professor deduced the following important conclusions:—

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* Since the above passage was written, I have been pleased to find this view corroborated by my friend, Dr. Hooker, whose duties as botanist to the Antarctic Expedition would give him ample opportunities for observation. In his paper " On the Vegetation of the Carboniferous Period, as compared with that of the present day," he says,—" A luxuriant vegetation is, however, no index to a *varied* one; and as many of our modern woods, and even great area of tropical forests, consist of but a few species multiplied *ad infinitum*, so may the forests of the carboniferous period have been composed of but a few Sigillariæ and Lepidodendrons, sheltering an under-growth of a limited number of kinds of Fern."—*Edinburgh Philosophical Journal, vol.* xlvi., *p.* 77.

"1st. That Dicotyledonous plants in general are not able to remain two years in water without being totally decomposed; and that the principal part of those which do possess the power are Coniferæ and Cycadeæ.

"2nd. That Monocotyledons are more capable of resisting the action of water, in particular Palms and Scitamineous plants, but that grasses and sedges perish; so that we have no right to say that the earth was not originally clothed with grasses and other plants of a similar nature, because we no longer find their remains."

Brongniart, however, (no mean authority on this subject,) advocates the contrary opinion. "The living vegetable kingdom," he observes, "consists of five great divisions, the Cellular Cryptogams or Amphigens; the Vascular Cryptogams or Acrogens; the Dicotyledonous Phanerogams; Gymnosperms and Angiosperms; and the Monocotyledonous Phanerogams. Of these five divisions, the *three* first evidently existed at the Carboniferous epoch; whereas the two last seem to have been entirely wanting; there is nothing, at least, which establishes, with certainty, their existence; and everything, on the contrary, tends to render it doubtful."

Estimating the present vegetation of the globe in round numbers at 80,000 species, the Fossil Flora amounts to about $\frac{1}{45}$ of the living Flora.

In 1828, only 500 species were enumerated by Brongniart from various parts of Europe. In 1845, Goeppert increased this number to 1792 species, belonging to 61 families and 277 genera, of which 816 belonged to the coal formation; and he has subsequently seen 50 new species in the collection of Graser, director of the coal mines near Aix la Chapelle, obtained from that locality alone. In 1837 about 527 species of fossil plants were described and figured in the Fossil Flora of Great Britain, by Messrs. Lindley and Hutton; of these no less than 268 belonged to the true carboniferous system, and 65 to the upper carboniferous beds in the Oolitic shale, near Scarbro', &c., making collectively, 333 species; a very large majority for *one* system out of the whole series through which the entire mass is distributed, and from which we must infer either that vegetation was more profuse and various at the period of the deposition of coal than at that of any of the more recent formations; (an hypothesis which appears to receive confirmation from the brief Prodromus of Brongniart, in 1828, who gives us the following enumeration and distribution:—Coal Measures 258, New Red Sandstone 19, Variegated Marls and Lias 22, Oolitic Series 49, Plastic Clay Formation 35, London Clay 16, Lower Fresh Water Formation 15, Upper Fresh Water Formation 6 species;)* or that

* In 1845, Goeppert published the following much more extended and comprehensive enumeration and distribution of fossil plants:—

	Families.		Species.
Transition or Greywacke	8	Algæ, Equisetaceæ, Asterophyllitæ, Filices, Stigmarieæ, Sigillarieæ, Lycopodiaceæ, Abietineæ,	52
Carboniferous Limestone	3	Filices, Stigmarieæ, Psaronieæ,	3
Coal formation	18	Fungi, Algæ, Equisetaceæ, Asterophyllitæ, Filices, Stigmarieæ, Sigillarieæ, Lycopodiaceæ, Cyperaceæ? Gramineæ, Palmæ, Liliaceæ, Asparageæ, Cannaceæ, Musaceæ, Cycadeæ, Diploxyleæ, Abietineæ,	816
Red Sandstone	4	Equisetaceæ, Filices, Psaronieæ, Aroideæ, ...	39
Magnesian Limestone, and Copper Slate	3	Algæ, Filices, Cupressineæ,	19

some cause protected the more ancient remains from destruction by the atmosphere, and prevented the carbon fixed in them from being lost. Now, with respect to

		Families.		Species.
	Variegated Sandstone	8	Equisetaceæ, Filices, Gramineæ, Restiaceæ, Liliaceæ, Cycadeæ, Cupressineæ, Abietineæ,	32
	Shell Limestone	2	Algæ, Filices, Neuropteris Gaillardotii, *Brongn.;* Caulerpites Brandowskranus, *Goepp.*	2
	Keuper	8	Algæ, Equisetaceæ, Filices, Restiaceæ, Asparageæ, Cycadeæ, Cupressineæ, Abietineæ,	52
	Lias	12	Fungi, Algæ, Lichenes? Equisetaceæ, Filices, Hydropterides, Lycopodiaceæ, Cyperaceæ, Gramineæ, Cycadeæ, Abietineæ, Cupressineæ,	75
	Jurassic Formation	9	Algæ, Equisetaceæ, Filices, Hydropterides, Lycopodiaceæ, Najadeæ, Pandaneæ, Cycadeæ, Abietineæ	159
	Wealden Formation	8	Algæ, Equisetaceæ, Filices, Palmæ, Lilliaceæ, Cycadeæ, Abietineæ, Cupressineæ	16
	Green Sand	15	Algæ, Filices, Lycopodiaceæ, Gramineæ, Najadeæ, Palmæ, Asparageæ, Cannaceæ, Cycadeæ, Abietineæ, Salicineæ, Myriceæ, Acerineæ, Juglandeæ, Crassulaceæ	59
	Chalk	1	Algæ	3
	Monte Bolca	4	Algæ, Najadeæ, Gentianeæ, Nymphæceæ	7
Tertiary Series.	Eocene	10	Algæ, Najadeæ, Pandaneæ, Cupressineæ, Proteaceæ, Cucurbitaceæ, Leguminosæ, Sapindaceæ, Malvaceæ, Aurantiaceæ	120
	Miocene, Molasse, et Pliocene	52	Fungi, Lichenes, Algæ, Characeæ, Musci hepatici et Musci frondosi, Filices, Hydropterides, Lycopodiaceæ, Gramineæ, Liliaceæ, Najadeæ, Typhaceæ, Ceratophylleæ, Pandaneæ, Palmæ, Cannaceæ, Asparageæ, Cycadeæ, Abietineæ, Cupressineæ, Taxineæ, Gnetaceæ, Acerineæ, Cupuliferæ, Plataneæ, Salicineæ, Betulineæ, Myriceæ, Ulmaceæ, Primulaceæ? Apocyneæ, Ebenaceæ, Oleineæ, Ericaceæ, Loranthaceæ, Caprifoliaceæ, Umbelliferæ, Halorageæ, Leguminosæ, Terebinthaceæ, Juglandeæ, Zanthoxyleæ, Rhamneæ, Coriarieæ, Acerineæ, Elatineæ.	327
	Geological position unknown	4	Algæ, Palmæ, Cycadeæ, Abietineæ	11
				*1792

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* Comptes Rendus, 1845.

the first of these theories, I would observe, that although a considerable diminution in number is evident as we proceed from the older to the newer strata, and still further, that plants of a different character almost invariably mark each succeeding epoch, commencing with those of a strictly tropical aspect and gigantic dimensions, which gradually disappear and give place to those of our own time, as Elms, Chesnuts, Sycamores, &c.; still I must again declare I cannot see that these facts afford sufficient evidence that a multitude of other plants were not co-existent with those whose remains are preserved, but rather of the perishable nature of the majority of them.

Connected with this subject there is another fact of great importance to be considered, that of the circumstances under which each peculiar group of fossil plants may have been deposited. The beds of coal, for instance, consist of one homogeneous mass of vegetable reliquæ, grown for the most part on the spot, and which, after accumulating for ages and undergoing a chemical change in fresh water, have been submitted to enormous pressure, the probable influence of igneous agency and the muriatic acid of the ocean! Here, then, we have a right to expect a tolerable number of different species of plants. But if we turn to the Lias, and other sections of the Oolitic series, we find only comparatively few plants, and those fragments, which have been transported with the clay, sand, or other materials, from a distance, and deposited singly or collectively, as the currents happened to be laden with vegetable debris. Neither of these instances, however, furnishes satisfactory data from whence we can predict as to the richness or sterility of vegetation at particular epochs; inasmuch as the former gives us only such plants as flourished in the localities where our coal fields originated, and the latter only a few of such species as grew in the districts through which the inundating current might sweep. But as regards the profusion of the individual species that did exist, there can be but one opinion; and in order to form a just conception of the luxuriance of vegetation at remote periods of the world as compared with the present, we have only to contemplate the masses of vegetable matter accumulated, and which have been converted into coal, covering many thousands of square miles in this country, as well as on the continent of Europe, measuring many yards in thickness, and several times repeated, as at the Saarbruck Coal Field, where there are 120 seams lying one over the other, exclusive of a host of smaller seams less than a foot in thickness; and then take into account the fact stated by Humboldt, that in the temperate zone of the present day, the accumulated growth of a forest in a hundred years would not, if converted into coal, cover the ground on which it stands much above half an inch thick; which teaches us, I conceive, that to profusion would most probably be superadded *rapidity* of growth and *brevity* of duration, features of no slight importance in the primæval flora; as these agencies would accelerate, to a great extent, the accumulation of an enormous bulk of carbon, from the short period that would hence be required for the successive reproduction of large masses of vegetation over a vast extent of country. Lastly, as another stimulus to excessive luxuriance of growth, I may add Brongniart's conjecture, " That the atmosphere, at the time of the deposition of the Carboniferous strata, was far more charged with carbonic acid gas than now; and that it was this which not only enabled gigantic species to develop at a time when there was little soil to support them, but also in some measure prevented their dead remains from being decomposed by the action of the oxygen of the atmosphere."

The 323 species of plants described from the coal measures of this country, (which is far, however, from being the actual number known in collections,) are not all found universally distributed, but, on the contrary, occur in particular beds or seams of coal, worked in different localities, some of which have been more accurately investigated than others; as, for instance, the Lancashire coal field, which alone contains, as Mr. Binney informs me, nearly *double* the number of species enumerated by Lindley and Hutton. This fact he attributes to the circumstance of the upper part of the series in Lancashire being exposed and more fully developed than is the case in Yorkshire and Durham; where about 700 yards of the upper coal field of Lancashire is covered up by the Magnesian Limestone, and contains several peculiar fossil plants, detected also in the Nova Scotia coal field, by Sir C. Lyell. The next whose flora is best known is that of the Newcastle and Durham, in which occur several species not, as yet, discovered in Yorkshire. This is also the case with that of Coalbrook Dale, so that each contains a few species unknown in the others. Hence, of the above number the proportions in those whose contents have been investigated, are pretty nearly as follows:—In the Newcastle and Durham we find about 87; in the Yorkshire, exclusive of the Oolitic series, about 72; in the Coalbrook Dale 75; while in the Lancashire portion will probably be found far more species. Of the coal fields, however, of Derby, Stafford, Whitehaven, Ashby, Warwickshire, Dudley, South Wales, Gloucester, Somerset, and the Forest of Dean, we know comparatively nothing as regards their flora; therefore a considerable accession of species may be expected when the shales from these districts have been examined.

From the enumeration I have just given, it will be perceived I do not confine my observations to the valuable working seams of the West Riding only, the source of so much wealth, and the main-spring of our manufactures, but embrace also those of the upper carboniferous shales and sandstones of the Oolitic series at Whitby and Scarbro'*; which, although from their geological superposition they do not belong to the true coal formation, are yet worked to supply the limekilns in some parts of the East Riding with coal; and possess peculiar interest from the singular fact, that not a solitary example of those beautiful plants which occur in such fine preservation at Haiburnwike, Cloughton Wike, Blue Wick, Gristhorp Bay, Whitby, &c., have ever been detected in deposits of an earlier period, such as the lower coal formation. Many of the genera are of a more tropical character, and are peculiar to the Oolitic series. A few of the species occur in the forest marble, but not after, and thus supply valuable diagnostic evidence of the identity of this formation, on the other side of the Atlantic, where in the Virginia coal field Pecopteris Whitbiensis, one of the most common plants of the Yorkshire Oolites, Equisetum columnare, Tæniopteris magnifolia, and Zamites, occur. Hence Mr. Bunbury infers that the Richmond beds belong to the same geological age as the Triassic or Jurassic series, and Mr. Lyell supposes they may be equivalent either to the inferior Oolite or Lias beds.† There is one remarkable circumstance connected with this rich deposit of plants I must not pass over, which is, that it is confined, with one or two exceptions, to this limited corner of the island. For, although the Oolitic beds in which they occur extend across the country, through Yorkshire, Lincolnshire, Northamptonshire, Rutland, Oxfordshire, Gloucestershire, Wilts, Somerset, and Dorset, these peculiar plants do not, neither do the beds of coal. A few of the same species occur in a somewhat similar deposit at Brora, in Sutherlandshire, and also at Hor, in Scania. The origin of this deposit (confining ourselves to that on our own coast) is a very difficult problem to solve, for whether we suppose the plants to have grown on the spot, or to have been transported by currents into some estuary or bay, we are equally beset with improbabilities. Yet to one of these two theories we must look for the solution. In the first place, could so small a portion of our island have had a peculiar flora during this epoch? This is barely possible to conceive, unless we assume it to have been *insular* during the above period. Or, in the second place, can we suppose that currents could throw masses of vegetables of a particular character upon this one district, and not spread simultaneously a portion of the same upon the contiguous and contemporaneous beds of Oolite and Lias, in the neighbouring counties? as Sir H. De la Beche thinks, who says "Circumstances must have existed at such situations, during a particular part of the deposit, not common to a considerable surface, such, perhaps, as sheltered bays, into which the vegetables were drifted, with mud and sand."* If, however, this last theory is adopted, the question arises, From whence were they drifted? as the locality could not be far distant, on account of the high state of preservation of most of the specimens; for here alone, I believe, have been found ferns with the Sori or masses of fructification on the back of their fronds, which long transportation would have dislodged. The stems, also, of Equisetum columnare, which here occur in the Sandstone in an erect position, would, as Mr. Williamson justly remarks, if this had been the case, be more disjointed and compressed, while, on the contrary, they often retain all their original roundness. As, however, we cannot point to the proximity of land, at the present day, where the same flora is more extensively distributed, as the probable site from whence they were drifted, are we to conclude that owing to considerable disturbing movements of the land at remote epochs, no part of such ancient continents or islands now appear above the surface of the ocean? which theory Professor Phillips appears to advocate, who observes, " Where, then, was situated that ancient land from which were swept the materials of the 1,000 yards of sandstones and shales which inclose the coal deposits in most parts of England and the continent of Europe? The slaty mountains of Cumberland, the Isle of Man, Cavan, &c., were perhaps above the water, but could they alone yield the materials for the argillaceous sediments, 1,000 feet thick, of Enniskillen, Derbyshire, and Craven? The Lammermuir mountains to the north seem not to be of such composition as would yield the coarse quartose sandstone; we must, therefore, appeal to the Grampian or Scandinavian ranges; or finally close all further discussion by admitting that *tracts of land*, which supplied part of the sediments, mixed with the limestone of the carboniferous period, *have disappeared from the northern and western oceans*."* Again, " May we venture to suppose that the primary tracts of the Scandinavian peninsula and Scotland, with other lands now sunk beneath the German Ocean, have been the sources of most of the arenaceous and argillaceous deposits of the Carboniferous, Oolitic, and Wealden formations of England? In this point of view, the local strata of Brora, the thick coal series of Bornholm, the Oolitic coal tracts of Yorkshire and Westphalia, the Wealden of Boulogne, Beauvais, Sussex, Dorset, and Wilts, are all partial and local deposits due to a similar succession of causes, and arising from the same or neighbouring physical regions, as the materials of some of the older coal strata. In Bornholm, coal occurs with marine beds of all geological ages, from the transition era to the cretaceous group; and the dependance of its deposits on the waste of the Scandinavian mountains is decided. The dependance of the other deposits on the waste of land to the north is a probable inference; and if we can imagine, what is probably true, that the Scottish and Scandinavian coasts were once united, the whole of the phenomena are intelligible as the varied deposits on the shores of one limited sea."* However conclusive this evidence may appear as regards the origin of the Sandstone and Shales, it does not, in my estimation, clear up the mystery regarding the original locality of the plants; for, even allowing that the shores of Scandinavia and Scotland were continuous at a remote period, as were also those of France and England; still if the plants were common to the former continent, we ought to find their remains more generally dispersed, as is the case with the flora of the old coal formation, over several hundred square miles; and on the other hand, if deposited by currents on its shores, we have still the site to discover, and also the cause of such limited patches only as occur at Scarbro', Brora, and Hor, while the whole extent of coast was equally subject to the effects of the ancient tidal waves.

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* It is to Messrs. Bean and Williamson, and Dr Murray, of Scarbro', Geologists are indebted for investigating this locality.

† See Quarterly Journal of the Geological Society, No. xiv., p. 47.

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* Geological Manual, p. 71.

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* Treatise on Geology, vol. i., pp. 178, 180.

In the synopsis of coal plants found in Yorkshire, which I am about to submit, I have thought it better to use the nomenclature of Brongniart, Lindley and Hutton, in most cases, as being that by which they are best known; although fully aware that some of these are no longer legitimate, having been used to designate as genera and species different parts only of the same plant found detached, or from separate localities, to which I shall have to allude.

Beginning with the *Vasculares*, the first plant which claims our attention, from its extensive geographical distribution and great abundance, is Stigmaria, which has probably been the subject of more diversity of opinion amongst geologists than any other fossil plant; from the different appearances it exhibits, and the supposed affinity it bore to various families of recent plants, with one of which it was desirable to arrange it. Owing, however, to the increasing attention paid to fossil botany, and the value attached to examining specimens in situ, it is now satisfactorily proved that the fossils known under the name of Stigmaria are really the *roots* of other larger plants. For this investigation and identification we owe much to the valuable researches of Mr. King in the Newcastle, Mr. Binney in the Lancashire, and Mr. Brown in the American coal fields. When I saw the first announcement, that Stigmaria had been found attached to the base of stems of Sigillaria so as to leave no doubt of their being the roots, by different individuals in distant localities, I felt persuaded it was only the beginning of this important discovery, from the fact that there is a great diversity in the appearance and external markings of the Stigmaria ficoides of geologists, so much so that, in some collections, the varieties have been specifically named. In some specimens, we see only a few depressed cavities or punctures, these distant and without apparent regularity; in others, these areolæ are deeper, more numerous, and with a distinct quincuncial arrangement. Sometimes, again, we see the areolæ few and small, and the interstices running into elevated striæ; and in one specimen belonging to this Society, the areolæ are situated in decided *hexagonal* depressions. As there are several supposed species of Sigillaria which differ essentially in sculpture, why might not the *roots* of these different species also present a diversity of character, and thus the *supposed varieties* of Stigmaria prove really *species*, or, more properly speaking, the roots of distinct species of Sigillaria or some other large plant? This conjecture has been recently fully confirmed by a communication made to the Geological Society of London, by Mr. Brown, of the discovery of upright stems of Lepidodendron with Stigmaria roots, in the roof of the Sydney main coal, in the Island of Cape Breton, North America.*

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* Treatise on Geology, vol. i., p. 217.

There are two characters in these Stigmaria roots which deserve notice, in which they differ from the root, I believe, of every known plant:—First, you never find any *small* Stigmariæ, indicating that this root branched out into very small subdivisions or fibrillæ, as is invariably the case in all other roots; secondly, that the lateral appendages, which were formerly supposed to be leaves, have each been attached to a small tubercle, and these generally arranged in regular quincuncial order, which is without a parallel, as far as we know, in the present flora of the globe, roots never proceeding from the main caudex with anything like symmetry, but being chiefly modified by the resisting nature of the medium in which they grow. If a further confirmation were wanted, that Stigmariæ are not the roots of Sigillariæ only, it is supplied by the fact of their being found of universal occurrence in every coal field throughout the world; whereas, even in this neighbourhood, Sigillariæ are not found in every locality, but, perhaps, replaced, in some instances, by Lepidodendron, Ulodendron, or Favularia.

Of Dicotyledonous wood, from some large trees, this Society possesses two or three distinct examples, the precise identity of which, however, I have never determined. One specimen, about five feet in length, much compressed, bears a great resemblance to the Pinites Brandlingi. The locality from whence received is unfortunately lost. A considerable quantity of wood was found in cutting through the sandstone for the tunnel at Darfield, on the line of the North Midland

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* Quarterly Journal of the Geological Society, No. xiii., p. 46.

Railway, and which retained its fibrous nature, although of considerable weight. Of true Coniferæ we have Thuytes expansa and Brachyphyllum mammillare, from the Oolitic coal field, near Scarbro'; Sphenophyllum erosum and Schlotheimii, from Gildersome and Wakefield; and a much larger species with the leaves more deeply cleft, which may probably be the dissection of Brongniart. Of Cycadian plants we have nine species, all from the Oolitic coal formation, as follows:— Cycadites Nilssoni, Zamia, gigas, lanceolatus, and longifolius, Pterophyllum comptum, minus, Nilssoni, Tenuicaulis, and Williamsonis. The last genus of Dicotyledonous plants, of which we have any remains, is Asterophyllites. These are the Asterophyllites, galioides, and foliosus, from Barnsley, tuberculata from Shelf, tenuifolia from Gildersome, and Equisetiformis from the mill-stone grit of Bramley Fall. Of Monocotyledons, (of which only a small number occur in the coal measures, and these possessing characters so indefinite as to render their affinity extremely doubtful,) we possess four genera, viz.:—Endogenites striata, (which, however, I do not believe is a *perfect* plant, but rather the central mass, similar to what is seen in Stigmaria,) Sternbergia, transversa, and approximata, from the millstone grit of Kirkstall, Weetwood, and Bramley Fall. Two very different opinions are entertained as to the real nature of this genus. Brongniart regards such stems as analogous to those of Yucca or Dracæna, considering the horizontal lines as the stations of leaves which have fallen off; while from observations made on specimens found near Birmingham, by Mr. Dawes, he is disposed to consider Sternbergia as the cast of the medullary cavity of stems or branches of large trees.* Poacites cocoina occurs both in the sandstone with Trigonocarpum, from Morley and Dewsbury, and the coal shale from Gildersome. That Poacites was really a species of Palm is more than probable, not only from its appearance, but also from the circumstance of its being found associated with Trigonocarpum, which is supposed to be the fruit of some plant of that family. The well authenticated genus of Palms, Nœggerathia, of which the flabellata and the foliosa, though occurring in the Newcastle and Lancashire coal fields, has never been detected in Yorkshire. Of the genus Trigonocarpum, we have a number of examples of Nœggerathii, from Dewsbury, Morley, Wakefield, and Darton. In one mass of sandstone is a cluster of about forty, as if separated from one branch, and as we might expect to be the case if a raceme of Palm fruit were broken up. The other species I have recognised appears to be the oblongum and Dawesii, from Darton and Pontefract; and another, apparently undescribed, about the size of a nectarine.

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* Proceedings of the Geological Society, vol. iv., p. 359.

From the second great division, *Cellulares*, to which the principal mass of the plants forming the fossil flora belong, I shall briefly enumerate such species as occur within our limits. Of the genus Equisetum, two, the columnaris and laterale, have long been known in the upper carboniferous series of the Yorkshire coast; but the dubius, although occurring in the Lancashire coal-field, has never, I believe, been observed here. In Calamites, however, this district is particularly rich, no less than fourteen species having been detected, examples of nearly all of which are comprised in the valuable series belonging to this Society, and that of the Philosophical Society of Leeds, exhibiting both the terminal portion, the root, crushed and contorted specimens, &c. These consist of cannæformis and approximatus from Chapel Allerton and Wentworth; decoratus, pachyderma, Steinhaueri, ramosus, and undulatus, from Low Moor; dubius, inæqualis, ornatus, Suckowii, and arenaceus, from the neighbourhood of Wentworth and Sheffield; verticillatus from Pontefract; and varians from Gildersome. Brongniart mentions, and figures a fragment from, a large species of Calamite whose locality was unknown, measuring about a *foot* in diameter, under the name of gigas. In the collection of this Society is also the lower portion of a very large specimen, which agrees with his figure in appearance, but is at least three feet in its longest diameter; this, however, is partially owing to the plant having suffered lateral compression, exclusive of which, it could not have been less than two feet. On account of its extraordinary size I should have considered this specimen, without hesitation, a Sigillaria, but the scars or punctures which are so characteristic of this genus are, in this specimen, absent, the stem presenting nothing but the parallel furrows. In Brongniart's figure, and also our own, the specimen is too short to exhibit satisfactorily the transverse septa or joint, so distinguishing a feature in the genus Calamites; but an indistinct approach towards this structure is partially observable on both. If this specimen is not a Calamite, what is it? as the lower portion of all the stems of Sigillaria which I have seen were not without the scars or punctures, and the commencement of the roots of Stigmaria have not the parallel ribs, but a striated appearance.

The true Ferns, at which we are now arrived, are, as I have before observed, the most abundant of all plants in the coal formation, almost every yard of the shale being more or less filled with their impressions. The fructification, however, which is so striking a feature in this class of plants, is almost universally destroyed by the long submersion, or other causes to which they have been subjected, so that the classification adopted for recent ferns cannot be employed for the fossil species, in lieu of which the venation of the fronds is made available.* That the majority of these were herbaceous is beyond doubt, but it is highly probable that some of the larger examples, as the genera Pecopteris and Neuropteris, constituted the frondose foliage of such stems as Sigillaria, Favularia, &c. In the first place, for the many hundreds of specimens of these genera found in every coal formation in Europe and America, which we know to have been stems, no foliage or flowers have ever been detected attached or detached, which appeared to have belonged to them; but, on the contrary, we do find, and not uncommonly, the fronds of ferns, or at least portions, whose magnitude would justify our supposition that they had originally formed the pendant summit of some of those lofty stems associated with them in the same bed of shale. In the Lancashire coal field Mr. Binney finds the Neuropteris heterophylla and Pecopteris lonchitica and nervosa, with Sigillaria; the same species occur in the Newcastle and Durham strata, according to Mr.

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* The subjoined characters of six genera which most frequently occur, will serve to explain the different modes of venation, &c., upon which the distinctions are founded:—

Pecopteris embraces those species whose leaves are once, twice, or thrice pinnated, the leaflets adhering by the whole base, or by the centre only, with a midrib running from the base to the extremity, veins proceeding from it at nearly right angles.

Neuropteris, leaves similar to the last, but more commonly somewhat ovate, attached by the centre only; the midrib does not reach the apex of the leaflets, but divides off right and left into veins, and gradually disappears.

Odontopteris, leaves like the last, but the leaflets adhere to the stalk by their whole base; no midrib; and the veins spring side by side at once from the base of the leaflet, passing onwards to the extremity.

Sphenopteris, leaves twice or thrice pinnatifid; the leaflets narrowest at the base, and wedge-shaped; the veins generally arranged as if radiating from the base.

Cyclopteris, leaves simple, either undivided or only lobed at the margin, more or less orbicular; midrib none; veins numerous, radiating from the base and forked.

Schizopteris, like the last, except that the leaf is deeply divided into numerous unequal segments, which are usually lobed and taper-pointed.

King; and in Yorkshire we find the same associated in the Wakefield and Barnsley pits. The first genus of true ferns, Pachypteris, contains but two species, lanceolata and ovata, which occur in the Oolitic shale near Whitby, and which is, I believe, the only known locality. Of the extensive genus Sphenopteris, we do not appear to possess many species. I have only detected nine; Sphenopteris trifoliatia, latifolia, and linearis, from Elsecar and Barnsley; fragilis, affinis, and dilatata, from Gildersome; obliqua, crenata, and obtusilobia, from Wakefield; to which may be added six species, Sphenopteris arguta, crenulata, denticulata, muscoides, hymenophylloides, and serrata, from the Oolitic series. There are still ten species which occur in the Newcastle coal field, which I have not recognised in Yorkshire. Of Cyclopteris, which have been creeping ferns, and perhaps approach nearer than any other to the existing genera, Hymenophyllum or Trichomanes, or some of the foreign Polypodiums, of which its species were gigantic representatives in the ancient flora, we have some good examples in this district. From the iron stone at Shelf, near Bradford, I have obtained Cyclopteris obliqua and orbicularis, two of the largest known species; the latter also occurs near Rotherham. The specimens found in the iron stone nodules are almost invariably single leaflets; but when we examine the Oolitic shales near Scarbro', portions of fronds eighteen inches in length, with the flexuose stem and leaflets, in situ of Cyclopteris Beanii, the characteristic features of the genus are very apparent. From the same locality may also be obtained Cyclopteris digitata and Huttoni, Glossopteris Phillipsii, Otopteris acuminata, and cuneata. The genera Neuropteris and Pecopteris, although both containing a large number of species, do not appear to be extensively distributed in Yorkshire. Those, however, that have been recognised, are tolerably plentiful in the particular localities where they do occur; of the former genus the most frequent are the Neuropteris, gigantea Loshii and heterophylla, at Gildersome, Wakefield, Rotherham, and Barnsley, where the latter acquires a tolerably large size, and is, perhaps, the best marked species, from the peculiar tendency of the leaflets to become subdivided, like the fronds of Osmunda regalis; the gigantea, however, is seldom perfect. In nodules of iron stone from Low Moor and Shelf, I have observed Villiersii and acuminata; and at Gristhorp, recentior and arguta. The genus Pecopteris, which alone contains above seventy species, has, I believe, only nine representatives within our district, the Pecopteris lonchitica, at Gildersome and Wakefield; serra at Newton, near Wakefield; the Serlii, nervosa, plumosa, heterophylla, and Miltoni from Elsecar and Rotherham, from whence remarkably fine specimens have been obtained, which though only fragments of fronds, by their magnitude and the diameter of their rachis, seems to justify the supposition already expressed, that they formed the herbaceous portion of some of the other vegetable giants entombed in the same strata. In the collection belonging to this Society are also specimens of Pecopteris Mantelli and urophylla, but from what part of the county cannot now be ascertained. To these may be added the following species from the lower carboniferous series at Scarbro':—Pecopteris, denticulata, exilis, Haiburnesis, Huttoniana, ligata, lobifolia tenuis, Whitbiensis, acutifolia, undans, propinqua, Williamsonis, obtusifolia, polypodioides; the last five of which exhibit the fructification peculiar to this family of plants in a very beautiful manner. In most of the early discovered specimens the thecæ were empty, but Dr. Murray, of Scarbro', has informed me that subsequently examples have been found with the cells perfect, and still containing the seeds, which is a highly interesting and important addition to our knowledge of these plants, and scarcely to be expected when the exceedingly minute and fragile structure of these bodies is considered, and that too in connexion with the vast period which must have elapsed since they were green and flourishing. The age and perfection of the finest mummies of ancient Egypt sink into insignificance when compared with these embalmed fern seeds. These microscopic records of an early world preserved in sepulchres more enduring than the pyramids themselves, cannot fail to call up a train of reflections on subjects of the most intense interest.

In Morris's catalogue of British fossils, Odontopteris Britannica is quoted as a Yorkshire coal plant, but without any precise information as to the locality; I therefore insert it, having full confidence in this author's accuracy. Of the anomalous genus, Schizopteris, one species has been found in the Oolitic shale at Gristhorp Bay,—by Mr. Bean, I believe, who has named it gracilis. The last genus of ferns of which we have any examples is Tæniopteris, plants much resembling in form the modern genus, Scolopendrium, but differing in the mode of fructification. Three species of this genus occur in the Oolitic shale of Gristhorp, the Tæniopteris major, ovalis, and vittata.

From the frondose portion of the ferns we now take those large vegetable remains, known under the names of Sigillaria, Favularia, &c.,* of whose real nature and affinity nothing positive is known. That the first entered very largely into the composition of coal is certain, from the abundance in which its remains occur in particular portions of every coal field in Europe and America; and that they were the giants of the primitive flora is also evident, from their greatly exceeding all other fossil plants in dimensions, specimens having been measured by my old friend, R. C. Taylor, Esq., in America, upwards of seventy feet in length. I have already mentioned the possibility that they might have constituted the stems of some of the larger ferns, not, however, for a moment confounding them with Tree ferns, (Caulopteris) though such was the opinion of Sternberg, and is still so of Brongniart, which theory has been ably criticised by Professor Lindley, who considers their true affinity as altogether doubtful at present, while Von Martius believes them to represent gigantic Cacti, Artis placed them with Euphorbiaceæ, and Schlotheim with Palms. Upon this diversity of opinion Dr. Hooker very judiciously remarks, "The necessary conclusion to which those who place them in the two orders, Cacti and Euphorbiaceæ, would lead us is, that they were inhabitants of singularly arid and desert countries, whilst, if Ferns, they are characteristic of diametrically opposite conditions,—a moist and humid atmosphere." Now the probability is much in favour of the latter, as the most conducive to the growth and rapid development of a profuse vegetation, such as we have indubitable proof existed at the carboniferous epoch. The same obscurity which hangs over the real nature of Sigillaria extends also to the legitimacy of the species, of

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* In order to familiarise the reader with the general appearance of these large stems, a slight analysis is here given:—

1. Sigillaria.—Stem furrowed, not branched, scars of leaves small, round, much narrower than the ridges of the stem.

2. Favularia.—Stem furrowed, not branched, scars of leaves small square, as broad as the ridges of the stem.

3. Megaphyton.—Stem not furrowed, nor branched, dotted, scars of leaves very large, of a horse shoe figure, much narrower than the ridges.

4. Bothrodendron.—Stem not furrowed, nor branched, covered with dots, scars of cones obliquely oval.

5. Ulodendron.—Stem not furrowed, nor branched, covered with rhomboidal marks, scars of cones circular.

6. Halonia.—Stem not furrowed, branched, covered with indistinct rhomboidal marks and tubercular projections.

7. Knorria.—Stem not furrowed, branched, marked with projecting scars of petioles disposed spirally.

8. Lepidodendron.—Not furrowed, branched, covered with lozenge-shaped scars in quincuncial order, each having a papilla in the upper part, the upper portion of the stem and branches with simple linear leaves, the lower portion destitute of leaves.

which a great many are recorded, that will eventually prove to be only different parts of the same plant. Out of a large number of specimens in the collection of this Society, it is very probable that only three species are included, the Sigillaria pachyderma, organum, and flexuosa, to which we may add catenulata, if really distinct, though I suspect it to be only a variety of pachyderma. It is worthy of remark that the state of perfection of the specimens depends very much upon the situation in which they are found; if in the coal or shale, they are crushed flat and prostrate, whilst if in the sandstone, generally erect, and retaining their columnar or round form. From the quarry at Altofts, near Wakefield, several fine specimens have been procured; one of Sigillaria flexuosa, in the Museum of the Philosophical Society, measuring nearly nine feet in height, was presented many years since by the Rev. Samuel Sharp, Vicar of Wakefield. Of the next genus, Favularia, which is far less frequent than the former, we find specimens of Favularia tessellata at Low Moor, Barnsley, Elsecar, and Shelf. In the museum of this Society are also several portions of large stems from the coal strata, from eight inches to two feet in diameter, without any of the external markings which characterise Sigillaria or Favularia.

Associated in the same group of plants with the two preceding, that is, as far as uncertainty of affinity is concerned, we have the genera Megaphyton, Bothrodendron, Ulodendron, Halonia, and Knorria, and from thence, probably, we may pass to the genus Lepidodendron. As to the proper situation of most of these genera considerable doubt exists, as but little of their history or real nature is revealed to us, further than that they embraced some of the most gigantic and lovely vegetable forms of the primæval earth, and that they reared their lofty and verdant summits over vast and untenanted forests, where human foot had never trod, or swamps whose awful solitude was, perhaps, only broken by the occasional croak of a Batrachian reptile,* and whose very flowers were probably never visited by the fairy forms of the insect world. To such early pages in the archæology of time must we turn for the period when these relics of vegetation were vigorous and green. If such is true, the sceptical philosopher will exultingly exclaim,—For what purpose was there such a lavish creation of the fairest and most graceful of nature's works spread around, when no being existed capable of appreciating their beauties and partaking of their produce? Botany unhesitatingly answers the question. Vegetable physiology declares to us in the most unequivocal manner, that it was through the agency of the countless millions of digestive cells thus provided and kept in action, the atmosphere was purified from the superabundance of carbonic acid with which it was loaded, and rendered fitting first for the respiration of reptile life, and lastly for man himself, whose creation closed this wondrous work.

The two genera, Sigillaria and Favularia, were characterised by furrowed stems, up which were arranged, in parallel lines, the scars of numerous leaves or ramenta, but without any indication of branches. The genera we have now to record, Megaphyton, Bothrodendron, Ulodendron, &c., have not this character, but have one very singular, and peculiar to the coal flora,—that of producing deciduous branches or gigantic leaves, which did not grow all round the stem, as in the generality of plants, but in regular super-position up each side, leaving a series of large scars, in shape like a horse shoe, to show the point of their attachment. The only species of Megaphyton found in Yorkshire is the distans, from the sandstone at Rawmarsh, which has also occurred at Newcastle. Bothrodendron punctatum has been found in some of the sandstone quarries near Wakefield, as well as in the shale, together with portions of the cone-like bodies, supposed to have grown from the obliquely oval scars or cavities on the stem. Of the genus Ulodendron, which, in many respects, resembles the preceding in the arrangement of a series of circular disks up each side of the old stem, we have the two most common species, Ulodendron majus and minus, from Low Moor, Wentworth, and Huddersfield. Were it not for this remarkable arrangement of the scars and disks, these stems would bear the closest resemblance to those of tree ferns.

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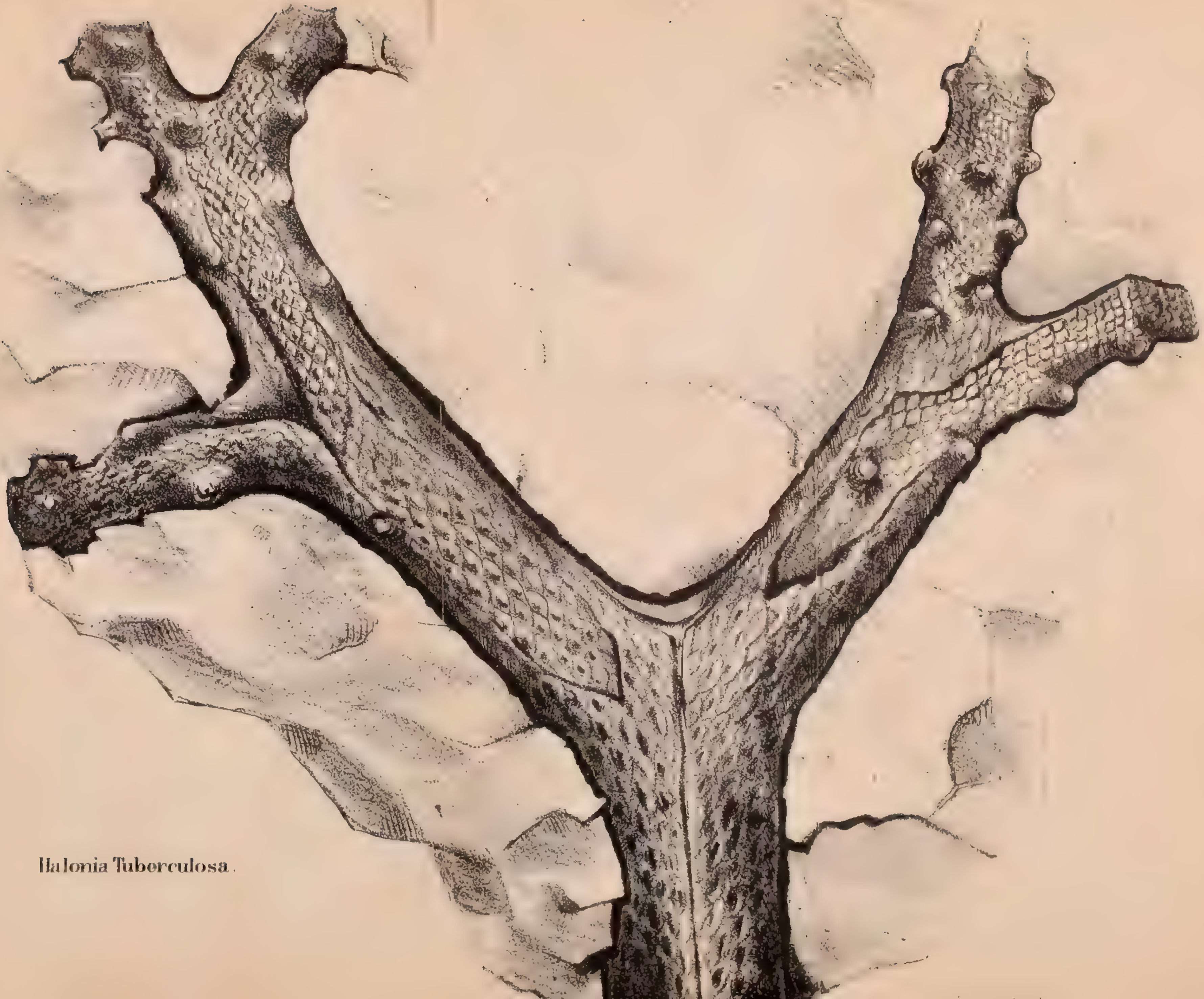
* Although I am not aware that any Batrachian remains have yet been found in the true coal formation, we have abundant evidence of the existence of enormous species in the very next deposit; the lower new red sandstone of Lancashire and Worcestershire, where the foot tracks of Labrinthodon are indelibly preserved; and Sir C. Lyell mentions the discovery, by Dr. King, in 1844, of reptile foot marks, probably of the same kind, upon sandstones in Pennsylvania, considered equivalent to part of the Paleozoic coal measures of the British islands; indeed the Greensburg sandstone occurs in the very midst of the Appalachian coal field, the main Pitsburg seam of coal being worked 100 feet above it. That Saurian reptiles existed at this period is satisfactorily proved by Von Dechen's discovery in the Saarbruck paleozoic coal district in 1848, of the skull and remains of three species of crocodilian lizard (Archigosaurus Decheni, medius, and minus) in nodules of ironstone.—*See Meyer on the Reptiles of the Coal Formation,—Journal of the Geological Society, vol. IV., part II., page* 51.

From the Ferns, whose real nature was evident, we next take the Lycopodiaceæ of Lindley and Hutton, so named from the supposition that the plants included under it were related to the Lycopodiums, or club mosses of the present day. That a few of them might be so is probable, but that the majority of them did, it is as improbable. Two species, the Lycopodites falcatus and Williamsonis, occur in the Oolitic shale near Scarbro', and are very possibly all which really bore any affinity to the above. The genus Lepidodendron contains a great many species which were supposed to be gigantic representatives of this family, and next to Calamites and Sigillaria, are the most abundant fossil plants in the coal formation. The most splendid species, Lepidodendron appendiculatum, occurs at Bank Top, near Barnsley, where a noble specimen, nearly forty feet in length, was broken up by the workmen in getting the stone for the inclosure of Barnsley Common. In the sandstone and millstone grit of the West Riding, the Lepidodendron obovatum is tolerably extensively distributed, fine specimens having been obtained from the Headingley Moor and Bramley Fall quarries. The Lepidodendron Sternbergia, elegans, gracile, and selaginoides, are not unfrequent in the shales at Gildersome, Barnsley, Elsecar, and Low Moor; quadrangularis at Bierley; and cœlata is also recorded as a Yorkshire species by Morris. Of the supposed cones of these plants, Lepidostrobus, examples of ornatus and variabilis are generally found in the same localities, and very frequently associated with a mass of leaves of Neuropteris, Pecopteris, &c. Of the genus Halonia, which, like Lepidodendron, probably holds an intermediate place between the Lycopodiaceæ and the Coniferæ, four well-marked species occur, the gracilis, regularis, tortosa, and tuberculosa, at Low Moor and Dewsbury. Of the last species one specimen in the possession of the Philosophical Society, procured from the sandstone at Potternewton, is the most perfect example I have ever seen, and possesses peculiar interest, as not only exhibiting the mode of branching of this genus, a point upon which nothing positive was known, but also apparently combining the characters of the genera Halonia and Knorria; the extremities of the branches belonging to the former, and the base or main stem to the latter.* Of Knorria, however, if really distinct, there are several large fragments in the Museum of this Society; but as little is known of the species, I have not been able to identify them. In Artis's Antediluvian Phytology is the figure of a plant having the scaly stem of the Lepido-

* Plate 1.



Halonia Tuberculosa.

dendron, found in one of the quarries on Swinton Common, near Rotherham, which is named Lychnophorites superus, from an impression that it was a Syngenesious plant, which I conceive to be an error, and, therefore, insert it amongst the Lepidodendra. In addition to the plants I have enumerated, there are several whose real affinities are very obscure, as, for instance, Hydatica columnaris, and prostrata, and Myriophyllites gracilis, from Elsecar; Pinnularia capillacea, from Shelf; Dictyophyllum rugosum, Solenites furcatis, and Murrayana, Sphœrococcites arcuatus, Sphœrida paradoxa, and Tympanophora simplex and racemosa, from Gristhorp and Cloughton.

Such is a brief list of the fossil flora of the Yorkshire coal-field, to which, I have no doubt, considerable additions might be made, if the various coal-pits in the district were examined with as much zeal and scrutiny as those in Newcastle and in Lancashire, where such harvests of specimens have repaid the labourers; the number of genera and species being much greater in both the other localities than with us; that is, confining our observations to the lower coal series, with which alone a comparison can be fairly made. As it is very desirable that we should possess a perfect list of all the plants which occur in the Yorkshire coal-field, I shall feel particularly obliged by additions to, or corrections of errors, which the Members of this Society, more especially owners of collieries, may be able to transmit me; or examples of doubtful species, by which means the Museum of the Geological and Polytechnic Society of the West Riding of Yorkshire may become the depository, as it surely ought to be, of an extensive and entire series of all the vegetable remains which occur in this district, which would supply information and instruction of the most important kind—geologically, as exhibiting the local treasures of the county, and morally, by means of these silent monitors pointing us to a lesson from the pages of time, from which we learn (to use the impressive language of Mrs. Somerville) that "The earthquake and the torrent, the august and terrible ministers of Almighty power, have torn the solid earth and opened the seals of the most ancient records of the creation, written in indelible characters on 'the perpetual hills and the everlasting mountains.' There we read of the changes that have brought the rude mass to its present fair state, and of the myriads of beings that have appeared on this mortal stage, have fulfilled their destinies, and have been swept from existence to make way for new races, which in their turn have vanished from the scene, till the creation of man completed the glorious work. Who shall define the periods of those mornings and evenings when God saw that his work was good? and who shall declare the time allotted to the human race, when the generations of the most insignificant insect existed for unnumbered ages? Yet man is also to vanish in the ever-changing course of events. The earth is to be burnt up, and the elements are to melt with fervent heat—to be again reduced to chaos, possibly to be renovated and adorned for other races of beings. These stupendous changes may be but cycles in those great laws of the universe where all is variable but the laws themselves, and He who has ordained them."

The next Paper read was—

ON IMPROVEMENTS IN THE GALVANOMETER, AND ON THE COMPARATIVE ECONOMY OF VARIOUS VOLTAIC ARRANGEMENTS. BY W. SYKES WARD, ESQ., LEEDS.

I intend in the following paper to draw the attention of this Society to some alterations I have made in the galvanometer, which was the subject of the communication made by me at the meeting at Pontefract, in 1847, and to add some suggestions as to methods of applying it, in ascertaining the comparative merits of various forms of the voltaic battery. I have also thought that it may be acceptable to those who are in any manner interested in the subject, that I should, at the same time, explain somewhat more fully some of the more practical and important deductions from Ohm's law. My ideas may not be found altogether original, but Ohm's essay on "The Galvanic Circuit investigated Mathematically," is not very accessible, being only published in Taylor's Scientific Memoirs, and is little, if at all, noticed in the more popular English works on electricity and galvanism.

Some of the methods of ascertaining the constants of voltaic combinations which I shall also produce, are similar to, or derived from, those of Professor Wheatstone, which were published in the Philosophical Transactions, but which I fear are not so generally known as is desirable.

I have, since the date of my paper before alluded to, found it more convenient to place the coil of my galvanometer in a horizontal than in a vertical position, as this more readily permits the changing the coils without disturbing the position of the magnet; and as it is convenient for the sake of increasing the dynamic power, and thereby the delicacy of the indications of the coil, to use compound magnets, of which two are placed side by side thus, U U, the axis of the coil being between the two. I also find that for most purposes it is advisable to have two coils adapted to the instrument, one consisting of about 10 feet of copper wire, of No. 20, Birmingham wire gauge, of which one foot weighs 27.4 grains, for estimating quantity; and another of 100 feet, of about No. 35, or $\frac{1}{120}$th of an inch, of which one foot weighs .97 grains, for estimating the intensity or electromotive force. For the former, wire covered with cotton is sufficient; the latter should be well, but lightly, covered with silk. Several coils or bundles of wire similar to that of the moveable coils, and of precisely the like resistance, should likewise be provided.

The most important alteration which I have made in the galvanometer is in adjusting it so that its indications may be referred to as an uniform standard. If we could with certainty procure magnets of precisely the same power, a standard pattern might be agreed upon for the coils, and uniform instruments procured. We can, however, readily modify the value of the indications in weight, by altering the length of the arms to which the scale pans are attached; and I propose that the galvanometer be adjusted to a common standard, by making a grain weight, supported by the 10 feet coil, the equivalent to one grain of zinc consumed in a single voltaic combination in one hour.

The galvanometer may, therefore, be adjusted by taking a pair of elements. The zinc being weighed, complete the circuit with a galvanometer; let the action continue for one hour, or any convenient part of an hour, from time to time observing and noting down the weights counterpoised by the current, and obtaining an average by interpolation; the zinc being weighed, the ratio between the number of grains balanced and the number of grains dissolved will be ascertained; if this be a convenient number for reduction, the galvanometer will be retained in its then state, and the observations reduced; or the arms of the balance, which I have found to be sufficiently attached to the coil by shell lac, may be altered until the indications correspond,—grains balanced for grains dissolved.

This may, perhaps, be more easily rendered intelligible by a practical example. A small arrangement of the nitric acid battery being used, in which a sheet of platina surrounded the porous cell, and a narrow strip of zinc well amalgamated was placed within the cell,—in the first instance the zinc weighed 114 grains.

At 8h. 27m.	the galvanometer balanced	57	grains.
„ 35	ditto	54	„
„ 40	ditto	58	„
„ 50	ditto	57	„
„ 57	ditto	57	„
		5)283	
		56.6	

The zinc then weighed 83 grains, 31 having been dissolved; thus the instrument, instead of having balanced 62 grains on the average, had only balanced 56.6, and, therefore, required adjusting, either by altering the position of the magnet, or altering the length of the arms of the balance, which for this purpose are conveniently made of two thin slips of brass, each cemented with shell lac on thin pieces of wood, the pieces of wood being also cemented to the coil; thus the small brass arm being warmed in the flame of a lamp, the length of the arm from the pivot is easily altered, without affecting the wrapping of the coil.

The indications of the coil of 100 feet of small wire may, in like manner, be adjusted to a standard, by making the arms of the balance support 16 grains, by the electromotive force of a single pair of elements; of zinc in diluted sulphuric acid 1 to 10, and of platina in nitric acid; the results should then be nearly comparable with a table of intensities of various combinations, published by Mr. Joule in the Philosophical Journal. The observations thus obtained may also be reduced by multiplying the number of grains supported by such constant number; that in the case of the elements selected for a standard, the product divided by the resistances of the combination of metal porous cell and electrolites, plus the resistances of the galvanometer and connecting wires, may agree with the weight supported by the coil of 10 feet (namely, the grains of zinc electrolitically dissolved per hour).

Finding it very desirable to ascertain more precisely than I had before done, that the indications of the galvanometer are consistent with each other, and in strict relation to the quantity of the current passing, I adopted the following methods. In the first place a coil of the same length and thickness as the 10 feet coil of the galvanometer was provided, and as accurately as possible adjusted to the like resistance as the galvanometer coil, by means of a differential resistance measurer (Wheatstone's). I found that the mere measuring similar lengths of wire from the same bundle was not sufficient, inasmuch as the connexions, although made by good binding screws, varied the relative resistances. Such coil was attached so as to divide the circuit with the galvanometer coil. Another length of wire, of about five feet, was added to the circuit, and its resistance adjusted so that the resistance of the five feet coil, and of the two ten feet coils, side by side, were equivalent to the original resistance of the galvanometer.

A pair of elements being put in circuit, the galvanometer in its ordinary state balanced 58 grains, the dividing coil being attached, and also the 5 feet coil, to equalise the resistance, as before-mentioned; exactly one-half of the current, of precisely the same quantity as before, passed through the galvanometer coil, which then balanced 29 grains; and on repeating the experiment with a smaller pair of elements, the undivided circuit balanced 38 grains, and the divided circuit 19 grains; thus proving that within very considerable limits, the weight balanced by the galvanometer may be relied on as indicating the quantity of current passing.

It appeared also desirable to ascertain the relative indications of the galvanometer as compared with the voltameter.

According to the experiments of Professor Daniel, 11.26 grains of zinc, electrolitically dissolved, should give 25 cubic inches of mixed gases; and I found this proportion more practically accurate than the one I deduced from the generally accepted tables of equivalents. Therefore 27.024 grains borne by the galvanometer, if correct, should equal one cubic inch of mixed gases per minute, and on these data I obtained the following results; in the first instance using a nitric acid battery, of which each cell balanced about 132 grains, being put in circuit with both voltameter and galvanometer:

No. of Cells.		Grains.	Cubic Inches per Minute.	Cubic Inches by Calculation.
4	Balanced ...	84	3.1	3.11
3	Ditto ...	62	2.3	2.29
2	Ditto ...	30	1.07	1.1

A series of much smaller cells being used, of which each cell with the galvanometer alone balanced 36 grains:

No. of Cells.		Grains.	No. of Minutes.	Cubic Inches Observed.	Cubic Inches by Calculation.
4	Balanced..	23	3	2.4	2.55
3	Ditto	19	3	2.08	2.1
2	Ditto	9	5	1.62	1.66

Although the discrepancy of the observed calculated quantities is not considerable, I am of opinion that it arises more from the difficulty of reading very small quantities in the collecting tube of the voltameter, rather than from errors of the galvanometer, and that the current was in no experiment quite uniform, the collection of gas on the electrodes of the voltameter sensibly diminishing the quantity of current indicated by the galvanometer. I therefore arrive at the conclusion, that my form of galvanometer will give much more accurate indications than can be obtained from a voltameter, in addition to the advantage of giving its results more immediately, and interposing less additional resistance in the circuit.

I think it very advisable that for recording the efficient working of various modifications of galvanic batteries, three observations should be taken.

1. The electromotive force or intensity should be observed by the coil of 100 feet of fine wire, which, on account of its resistance being very considerable, will, as regards a single pair of elements, indicate the electromotive force of the combination, without regard to the size of the elements, unless they be extremely small, or the resistance very great; but if it be required to ascertain the electro-motive force of a numerous series, several multiples of the resistance of the coil should be added in the circuit.

2. The dynamic effect, or quantity of the combination, should be observed by the weight supported by the 10 feet coil.

3. The battery resistance, that is, the resistance of the combination of the electrolyte and porous cells, if any be used, should be observed. For this purpose I propose two methods, derived from those of Professor Wheatstone, but which, I think, will be found somewhat simplified, both as regards the apparatus and the manipulation required.

One method of ascertaining the battery resistance is by putting in the scale half the weight supported by the 10 feet coil (as before), and then adding to the circuit a length of wire until the half weight be balanced. It is then obvious, according to Ohm's law, that the resistances of the circuit have been doubled; the equivalent of the galvanometer coil (10 feet), and also of the necessary connecting wires, being deducted, the remainder will be the equivalent of the battery resistance.

Another method is to divert half the current from the moveable coil, by putting an equal resistance by its side, and observing the weight balanced, then remove the diverting coil, and add wire to the circuit until the same weight be balanced. In the first instance half the current was employed; in the second the force of the whole current was reduced to half, by doubling all the resistances; but the resistance of the galvanometer was doubled by removing the diverting coil; therefore, the added resistance, minus the equivalent of the necessary connecting wires, is equal to the battery resistance.

The dynamic effect observed with the 10 feet coil will be equal to the effect of the battery reduced by the additional resistance of the coil, so that the apparent force of the current from a pair having a considerable resistance, will be too large in relation to the actual force of a pair having a smaller resistance. The observations should, therefore, be reduced by the proportion between the resistance of the battery, plus 10 feet, and the battery resistance alone.

The theory of the voltaic battery involves many points for consideration, as well of practical as of speculative interest; of the utmost practical interest in relation to the economical applications of the battery, as a source of motive power, and for the production of light, which have recently been so prominently brought before the public. Some points arising on this subject are also interesting, as showing that we may have a mathematical theory satisfactorily accounting for a great number of phenomena, and even enabling us to predict other phenomena, but which has, nevertheless, been derived from premises which other observers may believe to be false, and which they may think equally derivable from other premises. I allude to the theory of Ohm. I cannot briefly abstract the original paper, so as to point out distinctly the process of reasoning by which he deduced his theory, as his views, from adopting the contact theory of voltaic electricity, are so entirely at variance with my own, as adopting the chemical theory. According to the contact theory, the electro-motive force has its source in the contact of the metallic elements of the pile or voltaic arrangement, the chemical action of the fluids being merely accessory, and merely affecting the resistance, R. According to the chemical theory, the electro-motive force is developed by the chemical action of the electrolyte, the contact of the metals being only necessary to complete the circuit. The contact theory, I think myself justified in saying, has been mainly upheld on the continent on account of its appearing to be so fully borne out by Ohm's theory. The chemical theory has its results perfectly expressed by Ohm's law, and is supported by the strict correlation of the amount of chemical action taking place in the cells of the battery and the force of the current developed. According to the contact theory and Ohm's law, the effect produced is quite independent of the size of the elements, being the electro-motive force divided by the resistance, and expressed thus, $F = \frac{E}{R}$; but, on examining the resistance of the liquid portion of the circuit, we find that the resistance bears a strict ratio to the surface of the elements exposed to chemical action. The argument is, therefore, so far, equal and inconclusive on both sides. I now propose to present the principal equation of Ohm's law in a more expanded form:—$F = \frac{E}{R + r}$, in which R is the resistance of the electrolyte, and r that of the metallic or other resistances closing the circuit. It may easily be shown that the resistance of all conductors to the passage of the voltaic current is directly as the length, and inversely as the thickness or section, of the conductor. This holds good as regards the liquid, as well as the solid, portions of the circuit; therefore, instead of R we may substitute R′, the specific resistance of the electrolyte multiplied into D, the distance of the plates, and divided by S, the exposed sectional area. The formula, therefore, becomes $F = \frac{E}{\frac{R'D}{S} + r}$; but when the number of elements is increased, so as to form a voltaic battery, the formula becomes $F = \frac{n E}{n R + r}$, that is, the force equals the product of the number of elements divided by the number of battery resistances, plus the circuit resistance. We, therefore, deduce that if the r, the circuit resistance, be comparatively small, we obtain little more effect from a number of elements combined together in a battery than from a single pair of elements; and that if the length of the exterior resistance of the circuit be increased proportionally with the number of plates, we shall have the like effect from the battery as from the single pair. But, on the other hand, if the r or exterior resistance be large, comparatively, with the R, or resistance of the liquid element in a single cell, we shall obtain a considerable increase of effect by increasing the number of elements in combination. We, therefore, see that the law strictly agrees with the practice; that when considerable resistances are to be overcome, for instance, the decomposition of water, the passing a shock through the human body, or the transmitting the current to a distance, as in the electric telegraph, a considerable number of elements must be used in combination; but where a considerable quantity of electricity through a short circuit, as for many experiments in electro-magnetism, or for heating a short length of thick wire, is required, plates of considerable size and few in number, and having only a slight resistance, are sufficient. But when we require to produce powerful galvanic effects at a distance, requiring current in great quantity, and passing through long or imperfect conductors, a combination of considerable extent, both as regards the size and also the number of the elements, is required.

Although the foregoing equations enable us to ascertain the amount of force or effect derivable from any voltaic combination, they do not assist us in the more important investigation of the cost of working such a combination; that is, the amount of zinc or other metal electrolytically dissolved, and of the quantity of acid or other electrolyte required in sustaining such action.

The theory of Ohm would lead us to calculate the expense as in direct relation to the force developed, as well in a combination of elements as in the case of a single pair. A hasty application of the fact that the force of the current is in proportion to the electrolytic action might also lead to the same conclusion.

There is, however, a material difference in the consumption of metal in a pair of elements and in a compound battery; in the first the force is as before shown, $F = \frac{E}{R + r}$, and the consumption of metal and acid is in proportion to the force; in the second, $F = \frac{n E}{n R + r}$, and the consumption of metal and acid is n F, that is, the equivalent of the force is consumed in each cell of the battery.

Although the rationale of the last-mentioned fact was, I believe, partly suggested by Volta, it is not to be found in many of the popular treatises; and as Volta's explanation is applicable to the contact rather than the chemical theory, and although it points out why the force is only equivalent to one cell, (though such fact was unknown to him,) it does not point out distinctly why the electro-motive force or intensity is increased in proportion to the number of pairs. Ohm's theory, on the contrary, demonstrates the increasing intensity as an accumulation of electro-motive force, but does not account for the consumption of metal in each cell.

I fear I may not be able to express my ideas very distinctly on this head, without drawing your attention to some elementary details. If we take a piece of zinc and a piece of platina, and place them in diluted sulphuric acid, connecting them so as to form a closed circuit of a single pair of elements; from whatever part of the circuit we consider the action as commencing, we shall have the following results; part of the water is decomposed into its constituent elements, oxygen and hydrogen; the oxygen unites with the zinc, and the oxide of zinc formed is dissolved by the sulphuric acid. A number of atoms of hydrogen, equivalent to the oxygen, uniting with the zinc, pass to the platina plate, and are then given off in a gaseous form. An electric current passes from the zinc through the liquid to the platina, and by the metallic circuit or communicating wire, from the platina to the zinc; and if, by means of the galvanometer, we examine the quantity and intensity of the current passing, we shall find the intensity corresponding to four grains supported by the hundred feet coil, and the quantity corresponding to the size and distance of the plates, and the length of the circuit through which the current has to pass; if we change either of the metallic plates, we shall find a difference in the electro-motive force or intensity, and a corresponding alteration in the quantity. If we substitute for a clean and bright surface of platina, a surface of platina, or silver platinised, that is, covered with platina in the form of black powder, we shall, without a change of intensity, have a considerable change in the quantity of the current; for the hydrogen, which, in the case of smooth platina, adhered to the surface, is now given off more freely. It therefore appears that the difficulty of getting rid of the hydrogen is a resistance to the chemical action, and to the current. Again, if we for the plate of platina substitute a plate of copper, immersed in a solution of sulphate of copper, forming Daniel's arrangement, the copper solution being prevented from mixing with the dilute sulphuric acid in which the zinc is placed, by a diaphragm of porous earthenware or other porous material, we shall find that hydrogen is not now given off at the copper surface, but that the sulphate of copper in the solution is decomposed, and metallic copper precipitated on the copper plate. On examining the current with the galvanometer, we shall find the intensity represented by from eight to nine grains (the sulphate of copper arrangement not being constant in intensity); thus the decomposition of the copper by the hydrogen diminishes the electro-motive force, which we may conceive to arise from the decomposition of the zinc, less by four grains than when the hydrogen is given off in a gaseous form. Again, if for the copper in sulphate of copper we substitute a plate of platina in nitric acid, a diaphragm being used as before, the nitric acid will be decomposed at the surface of the platina, water being formed, and a gaseous compound of nitrogen, containing less oxygen than nitric acid, is given off. We shall now find the intensity of the combination sixteen grains, thus affording, by twelve grains, less diminution of intensity than when the hydrogen is given off in a gaseous form; by eight less than when copper is precipitated by the nascent hydrogen.

We also find that with various metals there are various degrees of electro-motive force; and these, whether they be employed as the positive or negative element of the combination, appear pretty nearly to maintain a like relation to each other in the scale of electro-motive force. This will be seen on inspection of the accompanying tables, in which we shall find the electro-motive power of zinc to iron in sulphuric acid to be about 16 to 11.2, or 2.8 degrees more, whatever negative metal be used in combination therewith in the same cell.

But metals in voltaic combinations appear to acquire different relations of electro-motive force, (that is, according to the old form of expression, become positive or negative,) according to the other metal with which they are associated in a voltaic pair. Thus, if we associate copper with zinc in dilute sulphuric acid, as before-mentioned, the zinc is oxydated, and hydrogen is thrown off from the surface of the copper; the copper is not at all oxydated, but rather preserved, the current in the liquid passing from the zinc to the copper; but if we associate copper with platina also in dilute sulphuric acid, the copper is oxydized, and dissolved in like manner as the zinc in the former experiment, the current passing from the copper to the platina. And if, instead of a single pair of elements, we use a battery of considerable intensity, we may, by connecting a plate of copper with the copper or platina terminal, and a plate of zinc with the zinc terminal (*i. e.* making the copper the anode and the zinc the cathode), we may reverse the ordinary electrical condition of the two metals, causing the copper to be oxydated and dissolved, and the zinc to give off hydrogen. In like manner, as the voltaic current may reverse or diminish the electro-motive forces of metals, so also it can increase them. If we place two plates of copper in a solution of sulphate of copper, and in the first instance simply connect them, we have no action; but if we connect them as though in voltaic series, with a pair of copper and zinc plates, we shall find the two copper plates acting as voltaic elements, one plate being oxydated and dissolved, and the other having copper deoxydized and precipitated on it. On examining the current circulating in such double combination, we find the intensity not materially altered by the combination of the two copper plates. Thus in the compound battery each plate communicates its own degree of intensity to the plate in the next cell, in the series with which it is in connexion, in addition to the intensity which such next plate would of itself possess in a single combination. We may, therefore, understand how the intensity accumulates in a compound battery.

We have, however, learnt that in a single pair of elements the current passes from the zinc to the platina, (*i. e.* in the liquid;) the zinc, therefore, in an unclosed circuit, appears to be deficient, and the platina surcharged with electricity, and this, under favourable circumstances, may be ascertained experimentally; but when we close the circuit, the current circulates so as to produce equilibrium. Now let us represent the direction of the currents of two separate pairs of elements in a diagram, marking the direction of the currents, and then draw the connections as in series; we shall perceive that each neighbouring metal becomes closer to the circuit of the next; each pair of zinc plates receiving the current from the platina of the neighbouring pair, so that whilst the zinc plates No. 1 and platina No. 2, mutually exalt each other's electro-motive power, the quantity of current, or rather the electricity developed, is neutralized.

The power of any series of voltaic arrangements is proportionate to the quantity of zinc dissolved in each cell, so far as regards the effect on a galvanometer, an electro-magnetic machine, or in producing chemical decomposition; and the power of the battery, as regards the overcoming resistances to the transmission of its powers through conductors, or through substances to be chemically operated upon, is proportionate to the electro-motive force of the individual cells, multiplied by the number of cells. Therefore the consumption of zinc equivalent to a given amount of work, must be multiplied by the number of cells used, to enable us to institute a comparison of the various kinds of battery, with regard to the consumption of zinc in them; and having ascertained the consumption of zinc, the equivalent quantity of other materials may be deduced therefrom, either by calculation according to chemical equivalents, or, if such method be doubtful, from any uncertainty as to the nature of the secondary products, as is the case with a nitric acid battery, from actual experiment.

I have, according to the method before pointed out, tabulated the results of a considerable number of experiments with single pairs of elements. (See tables appended at the end). The combinations which I have examined comprise more than are practically required, and are mostly useful for the purpose of showing what forms of battery will not be available. These experiments also point out that Ohm's law, expressed in the equation $F = \frac{E}{R}$, is not to be relied on in calculating the practical working of batteries, unless it be seen that another condition be complied with, that is, that the facility of chemical action be fully equivalent to the electrolitic action required to take place, (maintaining the constancy of the electro-motive force). Thus, as regards the action of solution of potash, as the electrolite in contact with the positive of metal, we have a very high electro-motive force, a moderate resistance, but a totally inefficient arrangement; because the solvent properties of the potash on the positive metal are not capable of removing the oxide from the surface of the metal with sufficient rapidity to keep it in an efficient condition. In like manner in the other combinations, the action of the electrolite on some of the metals which are not very soluble in sulphuric acid, is not sufficient to maintain the electric action.

A very slight consideration of the tables may show that both for economy and efficiency we should not use any other metal than zinc, when an active combination is required; and even when a feeble but prolonged current is required, we cannot, with economy, substitute any metal for zinc, because we cannot, with iron, (the only other metal at all likely,) substitute a process equivalent to the amalgamation of the zinc, for the purpose of avoiding local action.

The combination which we should first notice is zinc and copper, as in Wollaston's battery; this, though apparently economical as employing a cheap negative metal, is one the least serviceable; for even when the zinc is amalgamated, a small portion of copper is dissolved, and then precipitated on the zinc, producing so much local action that more of the zinc is wasted than is effectively consumed; so that we can scarcely make any calculation of the comparative cost of such battery. It is, without doubt, the most expensive to maintain. And in the combination of copper and zinc, although the resistance is at first slight, the copper is soon covered with adherent bubbles of hydrogen gas, which materially increase the resistance, and, to a considerable extent, throw the copper surface out of action.

When platinized silver is substituted for copper, which constitutes Mr. Smee's arrangement, the improvement is very great. There is then no difficulty in maintaining the amalgamation in a good state, and avoiding local action for a considerable period; and the peculiar action of the deposited platina prevents the great accumulation of hydrogen, which stops the action when a smooth metallic surface is used; so that the average quantity of current may be estimated as about three times the amount given by simple copper and zinc, after the effect of first contact has subsided. And the intensity being taken, as represented, by 5.5, we will suppose that a certain number of plates are required for a given purpose; for instance, to produce the electric light between the points. To do this with the platinized silver battery, 100 pairs of plates would be required; and to produce a required light, the consumption of zinc in each cell is one grain per minute, or sixty grains per hour. Then $60 \times 100 = 6{,}000$. Let us take the price of amalgamated zinc at 6d. per pound, which I consider about correct, if the mercury be partially recovered after the plates of zinc are used. 32.3 atoms of zinc take 8 atoms of oxygen (which, being derived from water, cost nothing,) and 40 atoms of sulphuric acid. As the sulphuric acid of commerce contains about one-fourth of its weight of water, and as the acid cannot be completely exhausted, we will assume that each pound of zinc requires two pounds of sulphuric acid, in order to have the excess of acid which is requisite to maintain a sufficiently powerful action; adding the price of this to that of the zinc, we have about 8d. per pound, and the battery of 100 pairs as costing nearly 7d. per hour.

If we take the modification known as Professor Daniel's battery, we have the intensity of 10 instead of 5.5; and $5.5 \times 100 = 10 \times 55$; and we therefore have to use 55 pairs of elements instead of 100. Now the consumption of zinc in these will be $60 \times 55 = 3{,}300$, and should only cost about 3½d. per hour for zinc and sulphuric acid to do the required work; but, in addition to these, we have sulphate of copper consumed and metallic copper deposited.

By my calculation, founded on the equivalent of copper and zinc, in 250 parts of sulphate of copper we have 16 parts oxygen, 64 copper, 80 sulphuric acid, and 90 parts water. Now 64.6 parts of zinc are equivalent to 16 of oxygen. Therefore, as 64.6 is to 250 parts of sulphate of copper, so is 1 lb. of zinc to the required quantity of sulphate of copper,—3.87 lbs.; and taking 4d. as the price of sulphate of copper per lb., we must add to 8d., the cost of zinc and electrolite, 16d. (nearly) for sulphate of copper, making 2s. as the cost of electrolitizing the pound of zinc. The battery in question consumes 3,300 grains of zinc, and, therefore, costs about 11d. per hour. The zinc will, however, reduce the copper from its sulphate, producing a weight of copper nearly equivalent to that of the zinc, the value of which (if on a large scale) must be deducted. Taking the copper at 10d. per lb., we reduce the cost of working the battery to 6½d.

In calculating the expense of working a nitric acid battery, I find that we cannot rely on the method of chemical equivalents; for when Grove's battery is worked in a close vessel, so that the fumes given off are not mixed with the atmosphere, I have found that the gas evolved appears to be a mixture, neither free from the red colour of nitrous acid, nor having the property of becoming fully coloured, as the binoxide of nitrogen would when mixed with air; it is, therefore, an uncertain mixture. I have found it most advisable to ascertain the proportionate consumption of zinc and nitric acid by direct experiment. In doing so I found that the dilution of nitric acid had much effect on the economy, and that it was more economical to use a mixture of equal parts of nitric and strong sulphuric acid by about 35 per cent. than to use nitric acid alone. The following are the results of my experiments:—A porous cell was charged with 763 grains of nitric acid; the galvanometer included in the circuit at first indicated 76 grains per hour; the action was continued for three hours, when the galvanometer declined to 27. The nitric acid was then considered exhausted. The zinc, electrolitically dissolved, would be about 180 grains. The specific gravity of the nitric acid used was 1.315, corresponding to about 300 per cent. of pure acid. Such acid costs about 6d. per lb; so that the quantity of nitric acid correspondent to the consumption of 1 lb. of zinc would thus cost 2s. But, according to the experiments where nitric and sulphuric acids were used together, the cost might be 1s. 3d., or possibly the acid might be obtained so much cheaper as to reduce the cost to 1s.

And, to return to the former method of calculation, we have, with a nitric acid battery, an intensity of 16 instead of 5.5, and $5.5 \times 100 = 16 \times 34.37$. We have, therefore, to use 34 instead of 100, and the consumption of zinc would be 3,062 grains per hour, which will cost about 3d., and at the least 5d., for nitric acid, together 8d. We thus find that the cost of three forms of battery calculated to produce the same effect is very similar, being respectively 7d. for Smee's, 6½d. for Daniel's, and 8d. per hour for Grove's. I do not take into account the product of zinc, for I believe it to be nearly worthless.

APPENDIX.

The column E denotes the electromotive force as ascertained by the intensity, or 100 feet coil of the galvanometer.

The column F denotes the force as ascertained by the quantity, or 10 feet coil of the galvanometer.

The numbers in column R are the battery resistances, as measured by feet of copper wire, No. 20, Birmingham gauge.

Where two sets of numbers are given in the same column, the first is the indication on first contact; the second after the force had declined; the letter d also indicates that the force declined.

				E	F	R
PLATINA.	NITRIC ACID.	DILUTED SULPHURIC ACID, 1 TO 10.	Zinc	16.2	92.0	...
			Zinc amalg.	16.0	90.0	18
			Tin	11.6	69.0 to 50.0	...
			Iron	11.2	67.0	18
			Bismuth	7.5	32.0 to 5.0	...
			Copper	7.2	41.5 d	...
			Lead	7.0 d	0.5	...
			Antimony	7.0 d	2.0	...
			Silver	3.5	4.0 to 1.0	...
				E	F	
PLATINA.	NITRIC ACID.	SOLUTION OF POTASH.	Zinc	19.5	10.0 to 3.0	Could not be ascertained
			Zinc amalg.	19.2	6.0 to 1.5	
			Tin	16.0	25.0 to 3.0	
			Lead	13.4 d	10.0 to 2.0	
			Iron	12.8	10.0 to 5.0	
			Antimony	12.5	6.0	
			Copper	8.2	5.0 to 2.0	
			Bismuth	8.0 d	5.0 to 1.0	
			Silver	4.8 d	5.0 to 3.0	
				E	F	R
PLATINA.	NITRIC ACID.	SOLUTION OF COMMON SALT.	Zinc	17.5	76.0 to 62.0	31
			Tin	12.5	52.0	...
			Bismuth	9.1	48.5	...
			Antimony	8.1	1.5	...
			Silver	8.1	3.5	...
				E	F	R
COPPER.	SOLUTION SULPHATE OF COPPER ACIDULATED.	SOLUTION OF HYDROCHLORATE OF AMMONIA.	Zinc	8.8	20.0	52
			Zinc amalg.	8.5	17.0	52
			Iron	4.1	8.5	...
			Lead	4.1	8.0	...
			Tin	3.9	1.0	...
			Copper	1.3	1.0	...
			Silver	0.4	1.0	...

				E	F	R
COPPER.	SOLUTION SULPHATE OF COPPER.	DILUTED SULPHURIC ACID, 1 TO 10.	Zinc amalg.	10.0	33.0	37
			Zinc	9.8	30.0	...
			Tin	4.7	14.0	...
			Iron	4.2	13.0	...
			Lead	1.5	...	...
			Bismuth	1.1	2.5	...
			Copper	0.8	1.0	...
			Antimony	0.7	0.5	...
			Silver	0	0	...
				E	F	R
COPPER.	SOLUTION SULPHATE OF COPPER.	SOLUTION OF POTASH.	Zinc amalg.	12.5	12.5 to 4.5	...
			Zinc	12.2	10.0 to 3.0	...
			Tin	10.5 to 9.8	1.5 to 0.5	...
			Lead	7.2	12.5 to 1.5	...
			Iron	6.5 to 4.5	3.0 to 1.0	...
			Antimony	6.0	2.0 to 1.0	...
			Bismuth	3.0 to 1.5	1.0 to 0.5	...
			Copper	2.7 to 1.8	2.0 to 0.5	...
			Silver	1.0 to 0.6	0	...
				E	F	R
	PLATINIZED SILVER.	DILUTED SULPHURIC ACID, 1 TO 10.	Zinc	10.0 to 5.5	9.0	...
			Zinc amalg.	5.8 to 5.5	29.0 to 20.0	...
			Tin	1.8	2.0	...
			Iron	1.3	1.0	...
			Copper	1.5 to 0.3	0.5	...
			Silver	0.8	0.1	...
	SILVER.		Zinc amalg.	4.7	15.0	29
			Zinc	4.3	15.0	...
			Iron	0.8	0.5	...
			Copper	0.5 to 0.3	...	...
	COPPER.		Zinc	7.8 to 3.5	11.0 to 7.0*	...
			Zinc amalg.	7.5 to 3.2	11.0 to 7.0†	...
			Tin	3.6 to 1.0	6.0	...
			Iron	2.8 to 0.8	6.0 to 0.5	...
			Lead	1.2 to 0.7	...	...
			Bismuth	3.0	...	...
			Antimony	0.2 to 0.1	...	...
			Platina	0.4	...	...
	IRON.		Zinc amalg.	4.8	17.0 to 15.0	...
			Zinc	4.8	15.0 to 14.0	...
			Tin	0.2 to 0.1	...	...

* Slow d.

† Rapid d.

				E	F	R
CAST IRON.	Nitric Acid and Sulphuric Acid.	Diluted Sulphuric Acid, 1 to 10.	Zinc	17.3	73.5	...
			Zinc amalg. ...	17.0	67.0	25
			Tin	12.5	54.5 to 20.0	...
			Iron	12.0	46.0	...
			Lead	10.0 to 3.0	1.0	...
			Copper	8.0	31.0	...
			Silver............	5.0	14.0 to 1.0	...
				E	F	R
AMALGAMATED ZINC.	Diluted Sulphuric Acid, 1 to 10.	Nitric Acid and Sulphuric Acid.	Cast Iron (Rod)	16.5	82.0	20
			Coke	16.2	54.0	...
			Platina (Small)	16.0	53.0	38
			Copper	11.8	53.0	23
			Lead	14.1	50.0	...
			Iron (Wire) ...	13.0 to 12.5	27.0 to 25.0	...
			Do. Cleaned ...	7.5	...	...

The following Paper was then read :—

ON A REMARKABLE BOILER CRUST, COMPOSED OF SULPHATE OF LIME. BY WILLIAM WEST, ESQ., F.R.S.

It has been common to speak of bicarbonate of lime, or carbonate of Lime dissolved in water by excess of carbonic acid, according to the opinions on a theoretical point, of authors describing the same substance, as yielding the crust or "fur" of steam boilers, and either to deny or overlook the share which sulphate of lime has in the formation of this troublesome deposit. Among those who have gone so far as to deny the existence, or at least the practical importance, of sulphate of lime in these crusts, is Dr. Ritterbandt, the proprietor of a very ingenious, and I believe in some situations a very effectual patent method for preventing incrustations of the carbonate, by introducing Chloride of Ammonium into the boiler.

At that temperature, carbonate of ammonia is driven off, and the highly soluble chloride of calcium remains, in place of insoluble carbonate of lime. I have, however, so often found in these crusts, not merely a notable, but a considerable proportion of sulphate of lime, that I have on different occasions, when my subject required, called attention to its presence, and expressed an opinion, which I have found much to confirm, that it is even more troublesome and mischievous than the carbonate alone. The specimen before you was formed, under somewhat peculiar circumstances, in a low-pressure boiler. It contains not a trace of carbonate, yields not a bubble of effervescence with acids, and its solution in a large quantity of water yields, with chloride of barium, a quantity of sulphate of barytes, closely equivalent to what it would furnish if pure anhydrous sulphate of lime. It contains a little iron. It is not the curious salt discovered by Professor Johnston, containing half an atom of water to each atom of sulphate of lime, (for ten grains, finely powdered, lost by exposure to a red heat, only three tenths of a grain,—less than a quarter of an atom of water), and therefore, hygrometric, or accidental; and the sulphate is essentially anhydrous. The deposition of sulphate of lime from a solution far below saturation takes place in a manner which I described some years ago, in the Journal of the Royal Institution. As each bubble of steam is disengaged during brisk ebullition, the sulphate of lime of course separates; for its re-solution time would be required, but before that can take place many other particles are separated, and these rapidly cohere into portions large enough to subside, and to resist yet more the solvent power of the water. I have elsewhere, and on other occasions, stated my belief that though gypsum, in its hydrous and ordinary crystals, is a softer mineral than calc spar, yet that boiler crusts containing much sulphate of lime are harder than those composed wholly or chiefly of carbonate. The present specimen curiously confirms this opinion. I am assured by the workmen that not only is it with difficulty removed by the tools usually employed for such purposes, but that even the "Sate," or hard chisel used for cutting cold iron, is sometimes broken or turned by this crust.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTY-NINTH MEETING, HELD IN THE TOWN HALL, DONCASTER, ON WEDNESDAY, AUGUST 29TH, 1849.

EARL FITZWILLIAM, having taken the chair, observed, that he should not attempt to inflict upon them anything like a speech. He should, therefore, content himself by calling upon Mr. Haywood to read his paper "On the Formation and Destruction of Limestone."

Previous to Mr. Haywood proceeding, however, the following gentlemen were elected Members of the Society:—

ROWLAND CHILDE, Esq., Wakefield.
GEO. CLARKE WALKER, Esq., Doncaster.
ARTHUR MARSHALL, Esq., Headingley.
WILLIAM SIMPSON, Esq., Thurnscoe.
GEORGE BRODRICK, Esq., Hamphall Stubbs.

The following paper was then read:—

ON THE FORMATION AND DESTRUCTION OF LIMESTONE, AND SOME OF THE MINERALS WHICH ACCOMPANY IT.

BY JAMES HAYWOOD, ESQ.

In referring to the earliest periods of this earth's history, we have positive evidence of its having once existed in a purely incandescent state; it consequently requires the assistance of very little chemical knowledge to convince us that such compounds as we now find upon its surface, could not then exist. We have ample proofs, from the every-day operation in our own furnaces, that the application of a violent heat to mixed mineral compounds alters their affinities to such an extent as to give rise to products of an entirely different character; such minerals as chalk, marble, or limestone rock, which consist of carbonic acid and lime, would lose that volatile acid at a high temperature, and caustic lime would be the result, as we find to be the case in the common process of burning. If, instead of heating the carbonate *alone*, we previously mix it with some of our sandstone, which consists principally of silica, we should not only expel the carbonic acid, as above stated, but a new compound, called silicate of lime, would be formed in its place. This decomposition is not confined to the carbonate of lime; any other salt containing a volatile acid would be acted upon by silica at a high temperature in a similar manner; hence we may fairly conclude that, during the igneous period just named, all the lime which now lies embedded in the form of limestone rocks, was then in the state of a silicate. Where, then, was the carbonic acid which we now find mineralised with this lime to an extent beyond calculation? Chemistry teaches us that not only this, but all the carbon which now lies embedded in the form of coal, and all that existing in the vegetation which now clothes the surface of the earth, was originally in the state of carbonic acid gas, and must, consequently, have formed part of the then existing atmosphere. Hence we are bound to admit, that the quantity of carbonic acid in the atmosphere, before the deposition of the carboniferous rocks, and prior to the existence of vegetable or animal life, was considerably greater than at the present time.

I can by no means reconcile myself to believing that the proportion extracted from the air during the deposition of the carboniferous series of rocks was so trivial as Liebig, in his

Agricultural Chemistry, would lead us to imagine; for when I consider the immensity of those beds which are deposited in various parts of the earth's surface, one of which in our own little island extends to a depth of some hundreds of feet, and occupies an area of several hundreds of square miles, we are bound to believe that some appreciable difference must have been produced; and particularly so when we further consider that every cubic foot of this limestone contains about 1,000 cubic feet of gas, every particle of which must have been extracted from the air. It is true that the present quantity of carbonic acid in our atmosphere amounts to about 3,867 cubic miles, or, estimated at the mean pressure on the earth's surface, to about 276 cubic miles; but this quantity, large as it may appear, is not greater than we find in a little more than one-fourth of a cubic mile of limestone. Hence every person conversant with the rudiments of geology must at once perceive that, in our own bed of mountain limestone, we have an amount of carbonic acid which, if set free, would increase the quantity in the atmosphere very considerably, and, together with that contained in our chalk, oolites, and coal, would probably increase it to five or six times its present quantity. But what is this compared with the whole surface of the globe? and what the mere basset edge of limestone, which is exposed to our mining operations, compared with that which we have every reason to believe extends far beyond our reach? A mere fraction! Then, I think, we may safely conclude that the quantity of carbonic acid which existed in the atmosphere prior to these depositions, was at least one hundred times greater than at the present day. Admitting this, we may then understand, independent of other considerations, why the globe, during the long period of its cooling, prior to the deposition of the carboniferous system of rocks, was not suited for the existence of animal life; and we may also explain the manner in which these rocks were formed when the process of cooling had been accomplished.

It is well known that when silicates of lime, potash, &c., are exposed for a long time to the action of water containing carbonic acid gas in solution, the silicates are completely decomposed, giving rise to a carbonate of these bases and gelatinous or soluble silica. This is a process which is slowly going on at the present day in all our cultivated soils, and is the one by which alkalis and silica are rendered soluble for the supply of crops. The carbonate of lime found in the springs rising in sandstone and granite, has its origin in this decomposition; and it would be no difficult matter for me to prove that at least two cwt. of silicates are thus decomposed in each acre per annum; for the product of the decomposition of two cwt. is required for the growth of each acre of wheat, and a much larger amount probably escapes by drainage.

If, then, decompositions to this extent take place in our own time, when the quantity of carbonic acid in the air and falling rain is so small, how much more rapid must have been such decomposition when the proportion of carbonic acid was so much greater, and the quantity of moisture condensed would bear no comparison to the showers of the present time! We have sufficient data to warrant us in concluding that the atmospheric changes were then very extensive; consequently torrents of rain and mighty floods would be the result, and these combined would wear away the crystalline structure of the igneous rocks, all of which are found to consist of alkaline, earthy, and metallic silicates, to an extent beyond our conception. We have seen that the result of the decomposition of silicate of lime would be carbonate of lime and silica. Now, carbonate of lime is an insoluble salt, and might easily be washed away by the streams and rivers, and embedded as mud at the bottom of the then existing seas, and so form a mass of rock on hardening. But these limestones do not present the character of having been so washed and deposited; they are all *crystalline*, and, consequently, must have been deposited from solution. Clay and sand, in all their forms, are instances of washed deposits. On examining them with a microscope, their particles always present a rounded and water-worn appearance, the true crystalline structure being destroyed. It is, therefore, evident that we must find some other explanation, more consistent with facts, to account for the formation of limestone; and it so happens that a process is going on at the present day, of the same nature (though limited in extent) to the one by which these rocks were produced, namely, the solution of carbonate of lime by waters containing carbonic acid gas. This solution may easily be effected by passing a stream of carbonic acid through water in which chalk or limestone is suspended, as in the manufactory of Carrara water.

I have shown before that the quantity of carbonic acid in the air, prior to the depositions of these rocks, must have been exceedingly great, and this gas being easily soluble in water, would be condensed by every shower. The rain which then fell would probably be a saturated solution of carbonic acid, and what could be the effect of this but *solution*—not only the *formation*, but the *subsequent solution*, of the carbonate of lime produced as above. In this state it would ultimately find its way into the then existing seas, and the water of these seas would shortly become a strong solution of carbonate of lime in carbonic acid, but the quantity of the latter might be considerably greater than the amount necessary to dissolve the carbonate of lime. This, in fact, would undoubtedly be the case, if we may judge from the composition of such waters as we now find them in nature, for in every instance with which I am acquainted the acid is in excess. It is, consequently, clear that a quantity of carbonic acid must be got rid of before any deposition can take place, and this would easily be effected by evaporation, for on boiling a solution of this character, or leaving it exposed for some time to the air, the gas escapes, and the carbonate having nothing to hold it in solution, is deposited. The question, then, as to the manner in which carbonic acid escaped from these carboniferous seas, is very easily solved. There can be no doubt that it was by the same process as I have just described,—namely, evaporation. The quantity of water evaporating from the sea is always proportional to the amount poured into it by rivers and rain; and any volatile body, like carbonic acid, contained in such water, would evaporate along with it; but fixed ingredients, like carbonate of lime, would be retained. It is, consequently, evident that the carbonic acid would be diminishing, and the carbonate of lime increasing, as this evaporation proceeded, and as fresh portions would be brought by the rivers year by year, a solution would at length be obtained exactly saturated, the removal of a little more carbonic acid would then cause crystallization to take place, and this would proceed as long as these seas existed and the supply of water to them was kept up.

I stated before that silica was rendered soluble during the decomposition of these silicious minerals; this substance would, consequently, find its way into the waters along with carbonate of lime, and might separate in a similar manner. Phosphate and some other salts of lime are also soluble in waters containing carbonic acid; hence we are able to account for the presence of these ingredients in limestone in general. Metallic salts of different kinds would be generated in the process of decomposition, and these would be carried in a soluble condition, or in suspension, and embedded in minute portions with the general mass;—hence they are always detected on analysis.

I would not by any means deny the agency of animal or vegetable life in promoting the formation of these rocks, for knowing what we do of the separation of carbonate of lime from our own seas by the little coral polype, and of the decomposition of carbonic acid when held in solution by plants and the lowest grades of animal life, it would be very unphilosophical so to do. And the very fact of the sea having teemed with animal and vegetable life in the form of encrenites, sponges, &c., at the time of the deposition of the mountain limestone, is a proof that they must have exerted some important influence on its formation. The decomposition of the carbonic acid was, consequently, another cause of the crystallization of the carbonate of lime, and a means of supplying an equivalent quantity of pure oxygen gas to the atmosphere, and hence preparing it for a higher grade of animal existence.

An annual destruction of a large number of this low grade of organized beings would necessarily take place, and their remains would be embedded in the crystalline mass. These remains would be subjected to the putrefactive process of decomposition, in consequence of the exclusion of atmospheric air; and this process has produced such an important alteration in the composition and appearance of these rocks, that were we not to take it into consideration, we should come to very wrong conclusions regarding their formation. It is well known that these rocks contain protoxide of iron, and some metallic sulphurets. Now as such compounds cannot be formed in the presence of oxygen, and as no animal can exist without an abundant supply of this element, it is clear that animal life could not be sustained in waters which deposited them. These metallic compounds could not, consequently, have been originally deposited as sulphurets or protoxides, but in some higher stage of oxidation. Now the process of putrefaction is well known to be a deoxidizing process, and is generally attended with the evolution of sulphuretted hydrogen gas; hence these metallic oxides have been converted into sulphurets, or reduced to a lower state of oxidation; the organic matter itself has been converted into a bituminous coal, which, disseminated through the whole mass, gives the stone, in some instances, a perfectly black appearance, as in black marble, and at other times a grey or slate colour.

A time at length arrived when the formation of this particular deposit, and the existence of its parasites, were brought to a close. Violent convulsions of nature uplifted the carboniferous bed of the ocean and converted it into dry land. The dislocations produced by this uplifting are still exhibited to us in the numerous fissures, caverns, &c., which exist in the limestone strata. These caverns and fissures were for a series of ages the receptacles for water and all soluble compounds which filtered through the new strata above. One of the constituents of such water would probably be that product of putrefactive decomposition,—sulphuretted hydrogen, and this would enable the water to dissolve a portion of these metallic sulphurets which I have shown the rock to contain. Now, if from any cause, such as the application of heat, or exposure to the atmosphere, this sulphuretted hydrogen should escape, then would sulphuret of lead and lime become insoluble; and, provided this escape was very slow, they would crystallize, as we now find them.

It is impossible to conceive that fissures like those in the mountain limestone could exist without some portion being exposed to atmospheric air; hence we have this simple mode of accounting for the formation of some of the minerals which accompany it. There is another cause, however, which, in the Derbyshire district, has been in extensive operation, and which enables us to account for the contents of these fissures more satisfactorily, viz., the agency of heat. It is well known that igneous matter, in the form of toadstone, has been poured out between the layers of limestone to a considerable extent. This heated mass would tend to evaporate all liquids contained in fissures within its influence, and, the process being a very slow one, the solids would crystallize in regular forms. It is a question whether these crystalline deposits of metallic ores, &c., were formed prior to the effusion of igneous matter between the limestone, or at the time it lay dormant beneath the whole mass. I think the continuation of the same lode above and below the toadstone is a sufficient proof that the formation occurred during the latter period, for had the fissure been open at the time of this igneous flood, it must undoubtedly have been filled; still the effect of this heat would be felt at the time the igneous mass lifted up the ocean bed to its present position, and it would not even be necessary to have recourse to its second or third effusion to account for these results.

Having attempted to explain the production of the sulphurets, I will now endeavour to give a brief outline of the formation of fluor spar, calcareous spar, &c. With regard to the first, I may remark that it consists of a simple elementary substance,—fluorine, and the metallic base of lime. I believe this substance is seldom or never found except in the neighbourhood of igneous rocks; hence we may premise that fluorine in some form or other must have been given off from the ignited mass itself. But it is well known that fluorine could not be given off in a free state if silica was present, because it possesses a very powerful affinity for its base,—silicon, and forms with it a volatile body,—the fluoride of silicon. Hence, if given off from igneous rocks at all, it must be in the form of this gas. Now, on bringing this substance in contact with water it would be decomposed, giving rise to hydrofluo-silicic acid, and free gelatinous silica, which latter becoming indurated, might take the form of chert. The irregular forms in which chert occurs in the mountain limestone afford a strong argument in favour of this opinion, for it has the very appearance of having been deposited where moisture or small streams of water occurred. The hydrofluo-silicic acid thus formed would decompose carbonate of lime forming the fluor spar in question, together with free carbonic acid gas. Now, fluor spar is soluble in free carbonic acid, and these two being the results of the above decomposition, we have ample means of conveying it into caverns, fissures, &c., where the volatile ingredients slowly evaporating, leave the fluor spar to crystallize. The carbonic acid, liberated by this decomposition, has the power of dissolving carbonate of lime as well as fluor spar, as I have before shown. Hence, the water filtering through these rocks would become saturated with this compound, and accumulating in any locality where the carbonic acid could evaporate, the carbonate of lime would crystallize in the form of dog tooth or other calcareous spar.

It is possible that the period in which these changes took place was one of long duration, and the formation of these crystals exceedingly slow. Indeed, it is necessary to admit that such was the case, in order to account for the production of such large crystals as these caverns frequently contain. We may easily conceive how slow the process would be, when we remember that a large mass of igneous matter, like the toadstone, would require ages to cool down, and, during its existence in a hot state, would probably be constantly furnishing materials for their formation. A time, however, would arrive when this process of cooling would be completed. Fluoride of silicon would cease to be evolved, and carbonic acid to be liberated; all further production of fluor spar and calcareous spar would here be arrested, and the putrefactive decomposition of these animal remains being also concluded, no further production of sulphuretted hydrogen, or formation of metallic sulphurets, could take place. The rocks would now become dry and permeable to atmospheric air, which by this time would have become rich in oxygen and poor in carbonic acid, by the immense quantity of the latter which was decomposed and deposited in the coal series. This oxygen would now act upon the portion of animal matter which had escaped the putrefactive decomposition, and a true process of oxidation, or decay, be established through the whole mass. Nor would this oxidation be confined to the organic matter alone: the metallic ores themselves would share the same fate, and in place of sulphurets we should have sulphates—in place of protoxides, peroxides or carbonates. New chemical agencies, therefore, began to operate and to pull down the fabric which had just been raised, and, shortly, a state of things occurred similar to what we observe at the present day.

It must be observed that the decay of these animal remains is an abundant source of carbonic acid gas, and this being a process now in operation, we are able to account for the large quantity of carbonic acid existing in spring water issuing from such rocks at the present day. As water containing this acid has the property of dissolving carbonate of lime, we may easily conceive that these rocks contain the elements of their own destruction. That they are, in fact, gradually dissolving away, and furnishing materials for the construction of new ones at the bottom of our present seas, is fully proved by the presence of a large quantity of carbonate of lime in all the springs issuing from such rocks, and in the rivers which they supply; although the proportion may be small as represented by a chemical analysis, amounting, on the average, to about ten grains per gallon, yet, when we consider the immense quantity which flows along most of our large rivers, it becomes immeasurably great.

It is calculated that the water daily consumed in London contains no less than 24 tons of carbonate of lime, or 8,000 tons per year; and this must be a mere trifle compared with the quantity flowing down the Thames and other large rivers in England. If we assume that one-third of the water which falls in the form of rain in our own island, after filtering through the soil and rocks, again finds its way into the sea, which has been found, from observations made with Dalton's rain gauge, to be nearly the case, and if we assume that each gallon of this water acquires ten grains of carbonate of lime, then we should have the enormous quantity of 192,000,000 of tons, or as much as would cover sixty square miles one yard deep, conveyed away annually by this process alone.

I admit that it is not entirely from these rocks that water acquires its lime; the disintegrated particles of other rocks forming cultivated soils is another abundant source. It is remarkable that most of our soils become exhausted in this valuable material in the lapse of time, and agriculturists find the necessity of restoring it as a manure. The primitive soil of the Lincolnshire wolds, alike with the Derbyshire hills, contains scarcely a trace of carbonate of lime, although they have been formed from rocks containing 98 per cent. No other cause can have removed this lime than the carbonic acid contained in this rain-water constantly filtering through them; and no other process could be more beautiful in nature or more adapted to the service of man; for by this very process, operating through a series of ages, are the minute portions of silicate of potash, iron, alumina, &c., separated from these rocks and left as a fertile soil; and hence the means of support to the existing race of animals is obtained, which the simple powder of the rocks themselves would never have afforded. How long a time this has taken to accomplish, and how much lime has been removed, you may conceive, when I state that in order to form a soil one foot in depth, such as we find on the Lincolnshire wolds and Derbyshire hills, the carbonate of lime must be removed to a depth of fifty feet. Now, supposing each gallon of water to dissolve ten grains, then the 5,168,756 gallons which fall on an average on each acre of land in this country would dissolve about three tons. We must remember that out of the above quantity of water falling not more than one-third, probably, finds its way into the sea, and, consequently, on this supposition, not more than one ton could be carried away from each acre per annum. Now this is precisely the quantity which the agriculturists of some parts of Lincolnshire consider requisite to restore to the soil in the form of marl, and pretty nearly the amount which I have found, on examination, to disappear. Hence we may conclude that the formation of soils from limestone rocks must have required not merely a series of ages, but a geological epoch to accomplish.

There is a beautiful instance of the decomposition of limestone exhibited to us in the mineral called rotten stone. This substance consists of the silicious and aluminous parts of the stone from which the carbonate has been removed, as above described. [A specimen in process of decomposition was here produced.] This decomposition had undoubtedly been produced in a sheltered position, or a substance of so friable a nature must soon have been reduced to ordinary soil by the action of rain or wind, as we find to be the case on the surface. In this manner is produced the carbonate of lime constantly dissolved from all our limestone beds and calcareous springs. When the water of such springs is exposed to the air, or made to run through mossy sedges, the carbonic acid gas escapes, giving rise to tufaceous deposits, or what is called petrified moss. When it drops from the roof of a cavern or runs down the side of a fissure, the gas also escapes, and we have beautiful stalactites and concretions which often add to the grandeur of these subterranean caverns, and contribute, in no small degree, to alter the character of the whole mass. A considerable quantity, however, finds its way into our rivers and ultimately into the sea, without being deposited; and hence our present seas should be gradually becoming saturated like the primeval ones. A similar little polypus is also busily engaged in these localities where the earthy matter is just on the point of being deposited, and there it is building up a beautiful fabric which is shortly to become an island, and ultimately to be subjected to a similar process of solution as those from which it is derived. Myriads of little mollusca also seize upon the limestone by destroying the carbonic acid which held it in solution, and transform it into a mass of shell, and these, after the death of the animal which produced them, is deposited with the general mass.

Changes of precisely the same character, though on a much less extensive scale, are in operation at the present time, as appear to have operated in the formation of limestone at an earlier period; altogether presenting to us a part of a wonderfully devised plan which cannot but excite our admiration. We observe the formation of this limestone tending to purify the atmosphere and rendering it suitable to the existence of man; changes taking place within its mass which furnish him with metals and other objects of his wants; and extensive decompositions on its surface which supply him with the very means of existence. And although we picture to ourselves a time when these hills will be reduced to level plains by the powerful agency of carbonic acid and water, yet we are bound to believe that these immeasurable masses are contributing to the formation of submarine deposits, which ultimately may become dry land, and, in their turn, become covered with luxuriant vegetation adapted to all his uses.

In reply to a question from William Aldam, Jun., Esq., Mr. Haywood said, that from an analysis he had made, he had come to the conclusion that if fifty tons of marl were placed on the lands in the Lincolnshire wolds, it would be washed away in about fifty years. At all events they would not find a larger quantity than was contained in the ordinary primeval soils which had not been cultivated at all.

ON THE GROWTH AND MANUFACTURE OF CHICORY. BY GEORGE WILKINSON, ESQ., OF BROOM HALL, NEAR SHEFFIELD.

Mr. Wilkinson commenced by describing the class, order, and character of the plant from which chicory was usually made; and observed, that its growth and manufacture was a subject which had recently attracted great attention, both from Parliament and the public in general; and as it was a production which was used to a very large extent in this country as a condiment with coffee, its consideration was a matter of no inferior importance. There were several species of chicory, but the one most cultivated in this country was the *Cichorium Intybus*, which also grows wild in the high roads and fields in the chalk districts of England.

Many had heard of the name of chicory, but comparatively few had either seen or tasted the plant. Having exhibited a specimen of chicory which had been grown at Attercliffe, he said, it might probably be asked, Why a plant containing such a large amount of succulent matter or herbage, should not be more extensively cultivated for the food of cattle? and on that point he would refer them to the facts which the late Mr. Martin had detailed at length respecting its agricultural properties.

The use of the pulverized root, as a mixture with coffee, first originated in Germany, and it was thence that the greater part of the chicory used for coffee was formerly obtained. The chicory grown in Germany was both cheaper and better than that grown in England. The way in which the root was prepared for mixing with coffee was as follows: the roots were first thoroughly washed, then placed in a cutting frame, and arranged by women to be operated upon by the cutters. After being cut into small pieces, a quarter of an inch in length, the next process was that of being dried. This was effected by the heat being transmitted through perforated tiles, or wire gauze, and the root was afterwards placed in iron cylinders, which were made to revolve over a fire of intense heat. It was then ready for pulverization, which was done by revolving stones; but it was sometimes ground by means of small iron mills. When in this state, it was sold to the grocer or retail dealer, by whom it was used to suit his own convenience, or the taste or price of his customers. And they would, perhaps, think it a remarkable fact, that, whilst coffee was often so largely adulterated with chicory, chicory itself was in its turn no less adulterated.

Mr. Anstey had stated, in the last session of Parliament, that a compound of burnt bread, burnt and mouldy biscuits, and burnt and ground rope yarn, were often palmed upon the public and substituted for the genuine article. In fact, it sometimes happened that in articles which were manufactured and sold as pepper, mustard, and chicory, none of them contained a particle of the real article. In no case was it possible to ascertain whether or not the chicory was entirely pure. The price and the respectability of the dealer would be the best test which they could apply.

Some parties had an idea that the growth of chicory exhausted the land, and destroyed the value of the succeeding crop; but, from careful investigations which had been made, so far from this being the case, it was found that the growth of the plant had added to the productiveness of the soil, and the farmers would find their other crops better than if they had not grown chicory.

In a commercial point of view, after noticing the time when coffee was first introduced into this country, in 1662, Mr. Wilkinson referred to the increase in the consumption of coffee from 1807, when the importation was upwards of one million pounds, to the last return, when it was thirty-six millions of pounds per annum. The quantity of chicory used was about eleven million pounds,—not a fourth of what was consumed in the name of coffee. Formerly, when chicory was scarce, it was bought in Germany at a high price, to improve coffee.

In answer to a remark, that chicory had nothing to recommend it but its cheapness, he would observe, that such a dictum involved its own negation, because cheapness was no recommendation for what was worthless. The foreign ingredient, coffee, he maintained, was improved rather than deteriorated by a mixture with chicory. And, so far as he was concerned, he should certainly say he should prefer an infusion of coffee with twenty per cent. of chicory, to that which was prepared without that article. With respect to its effects upon the system, it was admitted that chicory was good in a variety of ways.

In conclusion, he observed that rich light land was the best adapted for the cultivation of chicory, and clay land the most unsuitable. He had known land produce as much as fifteen tons per acre, and as little as nine tons. Ordinary land would produce about eleven tons, or two tons of manufactured chicory.

In reply to R. M. Milnes, Esq., M.P., Mr. Wilkinson said that, in respect to chicory as an article of farming, the price varied from £15 to £35 per ton. The ordinary price would be about £20 per ton in its manufactured state. The land would produce about two tons per acre, and the cost of cultivation would be about £12 or £14 per acre. It was said to be a profitable crop, and many farmers grew it in the neighbourhood of York.

Mr. MILNES said he had seen a large quantity growing in Suffolk, where there was a large mill for its manufacture into the article as required for use. In confirmation of Mr. Wilkinson's statement, as to the difficulty of getting genuine coffee, he might mention that in the East he hardly ever got any coffee which did not turn out to be West Indian coffee. The product of the East was so very small as to make it a very dear article. He believed the proportion of chicory mixed with coffee in France was extremely large.

Mr. WILKINSON said the quantity of chicory was twenty per cent. to the coffee. He had used it so for several years, and could speak to the fact that he had had no ill result from it.

ON MILK, AS AN AGRICULTURAL PRODUCTION AND AN ARTICLE OF FOOD. BY JAMES HAYWOOD, ESQ.

The milk of the cow, ewe, and goat has, from the most remote ages, been used as an article of food; but on account of the superior flavour of that produced by the cow, it has in modern times, in this country at least, been the only kind employed to any extent. The production of cows' milk has, in fact, now become the sole object of a very extensive and important branch of agriculture, namely, the dairy husbandry. It is a great commercial object in its natural form, as well as that of cream, in large towns, and a still greater commercial object in the form of butter and cheese in all the country districts; and in all its forms it constitutes a large article of ordinary diet to multitudes of the rural population. In order that I may the more effectually show its intrinsic value as an article of food, and point out the economy which would attend its more extensive use and abundant production, I will first describe its general chemical and physical characters.

On examining a portion of milk with a powerful microscope, we perceive that it consists of a transparent fluid, in which numbers of minute globules, of about the $\frac{4}{10,000}$ part of an inch in diameter, are seen to float. It is principally to these globules that the whiteness and opacity of the milk is owing. On leaving the fluid at rest for a length of time, the globules separate in a great measure from the fluid, and rise to the surface in the form of cream. This cream, however, does not consist entirely of these globules, but always contains a considerable quantity of the serous portion intermixed. It has been found on analysis to contain on an average in 100 parts:—

Butter	4.5
Curd	3.5
Whey	92.0
	100.0

It would appear, therefore, that milk might be divided into three distinct substances, namely, the butyraceous, the caseous, and the serous;—the butyraceous being the portion contained in the small globules, the principal part of which separates on repose; the caseous being the portion which coagulates in the formation of curds; and the serous being the portion remaining in the form of whey and butter-milk. In the process of churning the thin film which coats each butter globule is oxidised or broken, and the real fatty particles then liberated produce an uniform mass. This butter, however, is not perfectly free from caseous matter, nor can it be rendered so by the process of washing or melting. It is the presence of this small amount of caseine,—about sixteen per cent.,—that renders fresh butter so liable to undergo decomposition,—a change which can only be arrested by the addition of a large quantity of salt. Butter, when perfectly pure, possesses all the characters of ordinary fat, consisting of margarine and oleine; but has a different flavour from other fats, in consequence of the presence of three volatile oils, named butyrine, caprone, and caprine. These volatile bodies are probably formed from the odoriferous principles contained in the food consumed by the cow, as we find them very much modified by those acrid sulphur oils which exist in garlic, horse-radish, turnips, &c. The amount of butter contained in the new milk of the cow is by no means uniform, its quantity at all times depending on the kind and quantity of food consumed, the temperature to which she is exposed, the amount of exercise she takes, and the character of the animal itself.

All those vegetable compounds which are called elements of respiration, such as starch, sugar, gum, and oils, may be considered conducive to the formation of butter, for butter is merely the superfluous carbon and hydrogen of the food, which, like ordinary fats, remain unconsumed during respiration. Exercise, therefore, which renders it necessary for the cow to oxidize more carbon and hydrogen, to produce motion, and cold, which renders it necessary for the animal to burn more for the purpose of keeping up the ordinary temperature of its body, are both opposed to the formation of butter, while rest and warmth will be favourable to it. Butter, then, will be that constituent in milk which mainly supports respiration, and produces heat and motion in the animals consuming it; and as the quantity of respiratory food required by all animals which take severe exercise is much larger than that required for forming the organised tissue of the body, the presence of such a rich principle in milk is of the greatest importance, and is the one on which the young animal which consumes nothing else is mainly dependent for the support of these important processes.

There is another principle, however, in milk, which is also of considerable consequence in this respect, namely, the sugar. Sugar of milk is a white crystalline solid, possessing only a slight degree of sweetness, though of nearly the same composition as cane sugar, and of the same use in the animal economy. Ordinary milk is found to contain about 2.8 per cent. of sugar, which is equal in value, as respiratory food, to 1.4 lb. of butter; hence 100 lbs. of milk would be equivalent to 5.9 lbs. of fat, or to 11.8 lbs. of starch or sugar, in supporting respiration, and keeping up the heat of the body.

This milk sugar is a compound exceedingly liable to undergo decomposition, particularly if placed in contact with a body already in a state of change. The gastric juice of the stomach, or the infusion of rennet, which contains the principle of the gastric juice, converts it into lactic acid with great rapidity. The same change also takes place spontaneously in milk, if kept for a long time in warm weather, as we observe in the process of souring; and in this case, the other constituent of the milk—the caseine—becomes an insoluble coagulum. It would appear that the caseine in milk is held in solution by a small portion of free alkali, as we find distinct traces of caustic soda when new. A quantity of acid, sufficient to neutralize this alkali, always produces coagulation; and it is in this manner that the caseine is rendered insoluble in the stomach, or by the spontaneous formation of lactic acid in the milk. When the curds produced from milk are drained, well washed, and dried, they form the compound called caseine, of which good milk contains about seven per cent. This substance differs in composition from the two just described, in containing nitrogen as one of its constituents. It consists in 100 parts of

Carbon	55.74
Hydrogen	6.83
Nitrogen	16.14
Oxygen	21.29
	100.00

and is precisely of the same composition as flesh. It is, therefore, the true nutritive substance in milk, being the one from which all the organised tissue of young animals is formed. In milk it is probably in the best possible form for digestion, being suitable for nearly all stomachs, even those of the most tender age; but when dried, and partly decomposed, as we often find it in the form of cheese, although still of the same composition and adapted to the same purpose, it is not so easily dissolved and assimilated. The amount of this valuable nutritive principle in milk is found to vary considerably, and to depend, in a great measure, on the quality of the food consumed. The more nitrogen this food contains, the greater will be the per centage of caseine in the milk.

There are several instances recorded of grass being so poor that animals consuming it could not afford to secrete any caseine, in consequence of the whole of the nitrogen compounds being required for the ordinary vital processes. This is stated to have been particularly the case in certain cheese farms in the south, where it was found quite impossible to produce cheese until such ingredients as had been extracted from the soil had again been restored in manure, and, thereby, put it in a position to grow rich food again. The ingredients found most useful in regenerating this exhausted soil were bones. They supplied two of the most essential constituents of milk, namely, nitrogen and phosphorus, and, undoubtedly, contributed mainly to its normal production.

In addition to the sugar, fat, and caseine, before mentioned, we find in the serous part of milk considerable quantities of phosphates, chlorides, and other salts of potash, soda, lime, and magnesia; in fact, every element which has yet been detected as a normal constituent of the human body is found here in sufficient quantity and in the best possible form for supporting us in health and strength. 1,000 parts of milk is found to contain—

Water	857
Butter	39
Caseine	70
Sugar	28
Salts	6
	1,000

It would appear at first sight that this large per centage of water would render the milk very inferior as an article of diet; but when we inquire into the composition of flesh, potatoes, and other articles of food, we find the per centage of water in them very little smaller than named above. The lean part of butcher's meat contains no less than 74, and potatoes no less than 84 per cent. of moisture. Hence the difference is more imaginary than real.

Seeing, then, that milk contains all the elements of the human body in a state very little more diluted than we find them in our ordinary animal and vegetable food, let us now inquire if that valuable animal, the cow, is not capable of producing them for us at a much cheaper rate, and in larger quantity, in this form, than she could do in the form of fat and flesh; for, considering the ultimate object of agriculture to be the production of the largest amount of food from the smallest space of land, this question becomes one of considerable importance; for should the cost of producing a given weight of nutriment in milk be only half of that required to produce the same amount in butchers' meat, then it will become the duty of every farmer to facilitate the more extensive production of this commodity, so that all may be able to partake of its advantages.

It is now well understood that all the nutritive and respiratory principles required for the existence and support of animal life are formed principally by plants. The quantity of nutritive matter contained in these plants, however, is not found to be sufficient for the healthy existence of man; he requires that these principles should be put in a more concentrated form, and that part of them should be somewhat modified by the lower animals before they are suitable to his taste, and probably to his existence; hence, a considerable portion of his first produce is lost by supporting the lives of such animals as he chooses to make use of for this purpose. The amount of flesh and fat formed by a feeding cow or sheep is very small compared to the amount which it takes in its food, so that we do not, in feeding, obtain more than a fractional amount of what is contained in the vegetable produce. I find, from some of the best authorities, that the maximum amount of flesh which the best animal will put on, when fed on the most suitable food, is about 233 lbs. in 14 weeks; so that in one year animals of this kind, fed after each other, might produce 865 lbs. The food consumed in the production of this amount of flesh would be about

30 tons of turnips, containing 121 lbs. of nitrogen.
14 cwts. of linseed cake, containing 70¼ lbs. do.
Straw, *ad libitum*.

Now, in the food of the feeding cow we have nutriment represented by 191¼ of nitrogen, and in the flesh which it produces we have only twenty-four pounds of this element; hence a sacrifice of seven-eighths of the nutriment is constantly made in this, and a much larger portion, in most instances, where animals are reared and fattened. Surely in times like the present, when every article of food is of vital importance, and since, with a rapidly increasing population, it must annually become more so, this startling fact should lead to processes of greater economy; and I shall now endeavour to show that this economy may be easily attained by the more abundant cultivation of milk.

From information obtained from some of the principal cow-keepers in the neighbourhood of Sheffield, I find that a good cow will give, on an average, 2,000 quarts of milk during the first two months after calving, 1,000 quarts during the next three months, 330 quarts during the next one month following, and after this time about eight quarts per day for seven months more; she will then become dry for two months, and calve again: in the whole fifteen months, therefore, she will have given 5,000 quarts, or 1,000 gallons per annum. This milk having a specific gravity of 1.0324 will be about 10,324 lbs. in weight, and will contain

Dry caseine	722 lbs.,	equal to 2,578 lbs. of raw flesh.
Butter	402 lbs.	equal to 521 lbs. of fat.
Sugar	239 lbs.	

Hence the cow is capable of producing in milk, nutritive and fattening ingredients equal in amount to those contained in 3,099 lbs. of butchers' meat in one year; while cows feeding in succession, and consuming an equal amount of food to the milch cow, can only assimilate 865 lbs. in the same time, or which is very little more than one-fourth the quantity above-named. The amount of produce consumed by the milch cow will be something like the following, viz., ten tons of turnips, two tons of hay, two quarters of oats, five and a half bushels of beans, with chopped straw *ad libitum.* The amount of nitrogen contained in the whole of these substances is 170 lbs., and the amount of the same element contained in the nutritive constituents of its milk no less than 125 lbs. Hence, in this instance, we have but 45 lbs. expended in the vital animal processes, and a comparatively small amount wasted from the food consumed. The production of milk, then, simply considered as a means of rendering useful the nutritive constituents of plants, is more economical than the production of flesh, in the proportion of three and a half to one. And if we even estimate the money value of the food consumed, and compare it with the selling price of milk and butchers' meat, we shall find the profit to be very much in favour of the former. For, estimating the value of turnips at only 5s. per ton, we should have as the cost of the food of the milch cow:—

	£.	s.	d.
Ten tons of turnips	2	10	0
Two tons of hay.........................	8	0	0
Two quarters of oats	2	0	0
Five and a half bushels of beans ...	1	10	0
	£14	0	0

While the cost of the food for the feeding cow would be:—

	£.	s.	d.
Thirty tons of turnips	7	10	0
Fourteen cwt. of linseed cake at 10s.	7	0	0
	£14	10	0

The value of 1,000 gallons of milk, at 8d. per gallon, is £33 6s. 8d. The value of 865 lbs. of butchers' meat at 5½d. per lb. is £19 16s. 6d. It will, therefore, be seen that, although the fattening cow consumes food of the same, or even a greater value, and would require a greater extent of land to support it, yet the amount of saleable flesh which it puts on in one year does not sell for so much as the milk it is capable of producing in the same time by £13 10s. But this selling price of milk is by no means a fair representative of its intrinsic value. We must estimate the value of every article of food in proportion to the amount of nutritive and respiratory ingredients, which, on analysis, it is found to contain; and, if we take ordinary butchers' meat, costing 5½d. per lb., as the standard of comparison, then we shall find that 865 lbs. of such meat sells for £19 16s. 6d., the 1,000 gallons of milk, which contain nutritive and fattening ingredients equivalent to 3,099 lbs. of such meat, ought to sell for £71. Hence the profit is not only in favour of the producer, but very much so on the side of the consumer; for it will at once be perceived that he is purchasing in milk for £33 an amount of nutritive constituents for which, in meat, he would have to give £71. Hence it is evident that the humbler classes would derive incalculable benefit from a more extensive use of this valuable ingredient. It is, however, very much to be regretted that, in the rural districts, a small quantity only comes to their hands; farmers will scarcely give themselves the trouble to produce more milk than is required for their own domestic use, and the labourer is left to acquire a depraved taste for a decoction of one of the most *useless* productions imported into this country, namely, *tea*. I trust, however, that when they become more awake to the advantages which may be derived from a more extensive production of milk, and when railways enable them to distribute it uniformly to all parts of the kingdom, that they, with the liberality and philanthropy which has always distinguished them as a race, will give this boon to the class who are mainly dependent on their exertions.

ON IVORY, AS AN ARTICLE OF MANUFACTURE. BY GEORGE DALTON, ESQ., OF SHEFFIELD.

Ivory, the substance of the elephant's tusk, is a material with the appearance of which most persons are familiar. But few, perhaps, are aware that there are many varieties of this substance, differing materially from each other in composition, durability, and external appearance, and likewise in value; that they are differently affected by time, heat, and the atmosphere. It will, therefore, be the object of this paper to describe those differences.

The principal sources from whence our supply of ivory is derived are the Western Coast of Africa and Hindoostan, and, according to the source whence derived, it receives the appellation of African or Indian ivory. Each of these kinds is again subdivided into varieties, indicative of the locality whence derived. Gambia, Angola, Cameroon, Cape Coast, &c., are some of the African varieties; and Madras, Bombay, Siamese, and Ceylonese, some of the Asiatic varieties, each of them having some distinguishing character.

The most esteemed of all these varieties is the Cameroon; there is no other that is equal to it in beauty, durability of colour, and fineness of grain. The appearance presented by ivory of this description, when cut into pieces, is semi-diaphanous. The colour varies in different tusks from a milky white to a pale gold colour, which last is designated by ivory dealers transparent. In some of the best tusks this transparency can be distinguished even on the outside of the tusk. This kind obtains the highest price in the market, being from ten to fifteen per cent. higher than the next in order of quality. Although this kind of Cameroon retains its transparency for a longer period than any other, it eventually becomes white, and should there have been any blemishes hidden by the colour, those blemishes then become apparent; so that the milky white Cameroon is in the end the most beautiful, as it never changes colour, at least for a very long period, and is never deceptive in its appearance.

Some fastidious gentlemen, who imagine they have a thorough knowledge of ivory, will insist on having the handles of their table cutlery of the above transparent kind of ivory, thinking that by so doing they will be sure to obtain the best quality; but they know not that the import of Cameroon is very limited, and is not always to be had. The manufacturer in this case, to please his customer, will make him some transparent Cameroon out of Angola, by soaking it in water, so that a practised eye would not detect the substitute. But what the eye fails to detect the finger of time will soon indicate, for the water which had been forced into it, is evaporated by a short exposure to the air, and the defects which were hidden by the water then become manifest.

Gentlemen who purchase articles in ivory would do well, and be more certain to get what they want,—the best ivory, if they would not *insist* on having the transparent kind; for should they get the genuine article, it will eventually become white; so that, by taking the white in the first instance, they are not likely either to cheat themselves or be cheated by others. Whatever blemishes there may be in the white kind, they are always apparent to the eye.

It should be borne in mind that all transparent ivory is indebted for that quality to the water contained in its pores. But there is this difference, that, whilst the ivory which is made transparent by soaking in water, gives off that water rapidly on exposure to air, the other kind, which has received its water from nature during its growth, appears to retain it with greater tenacity, giving it off more slowly to the atmosphere.

The import of Cameroon ivory is very limited, and a considerable portion of it is purchased by French and German merchants, who outbid the English dealer, and select the best and straightest tusks. Besides its high price, there is great risk in purchasing Cameroon ivory; it is frequently intersected through its mass by circular rings of a different colour from the ground colour. Some tusks are much spotted, and, when cut, they have the appearance of what Geologists call "amygdaloid." The defects I have named reduce the value of the article 30 per cent., and the risk is such as to deter many manufacturers from purchasing it; for, unless the articles into which the perfect tusks are cut can be sold at a price that will cover the loss on the inferior, a tradesman is not safe in purchasing.

The variety of African ivory which approaches nearest to Cameroon in transparency and fineness of grain, is that which is imported from Angola; it is, in fact, the kind from which most of the better articles in the cutlery manufacture are made; and although its degree of transparency is not so great as that of the Cameroon, yet it is sufficiently beautiful in colour and fineness of grain to render it suitable for the best kinds of cutlery.

The coarsest of all the African varieties of ivory is that which is imported from the river Gambia. In colour it is generally white, and its texture is, in comparison with the two varieties already described, as oak to box-wood; even the central parts and the tips of the tusks, which, in all the varieties, are always the finest in texture, are not, in this kind, sufficiently so to render it suitable for any other than the commoner kinds of cutlery. I have seen large tusks of this kind covered on the outside with bark to the depth of a quarter of an inch.

Having now described three varieties of African ivory which present the greatest contrast to each other, I need not say anything of the others, except that they are of an intermediate character with those already described, but proceed to the Asiatic variety.

Zoologists have described the specific difference of the Asiatic and African elephants, but I am not aware that they have noticed the difference in the ivory produced by the two species. Those who are in the habit of working it can distinguish at a glance whether the ivory is the product of Africa or India.

In all the varieties of African ivory, (except one, to be noticed hereafter,) even in the whitest of them, there is a certain degree of transparency which is characteristic of it; but in the Asiatic varieties, the total absence of this quality is equally indicative of its Hindoo origin. Indian ivory is more homogeneous in colour and texture than African; the latter frequently exhibits in the same tusk pale yellow and white disposed in alternate circles round the centre, whilst the former is of a chalky whiteness throughout. This homogeneity of colour and texture is all the superiority that Indian ivory possesses over African, and even this character is not durable, but in a short period it changes to a dirty ochry colour; whilst articles made from African ivory (if they do not contain any of the outside or bark) improve in whiteness by lapse of time.

I alluded, a short time since, to another variety of ivory, of which nothing certain is known as to the locality whence it is derived; it bears the appellation of Egyptian ivory, from no other cause, that I am aware of, except that it is imported from that country; and as Egypt itself produces no ivory, it is very probable that it is floated down the Nile from Abyssinia or some of the neighbouring countries. It is, in fact, the production of the eastern part of the African continent, and presents a greater contrast from ivory the production of the western part of Africa, than even from that of Hindoostan, and has some peculiarities of each. It has the same opacity as the Indian ivory, but is considerably harder, and has a slight metallic sound when struck; yet its specific gravity is less than the Indian. It is only within the last two years that this variety of ivory has appeared in the market. The price of it has been about 15 to 20 per cent. lower than Indian ivory. But it is made full dearer than the latter by the greater amount of waste occasioned by a multitude of minute cracks, which cannot be seen until it is polished. Whether its superior hardness is a quality inherent in itself, or whether it is occasioned by dessication, I am unable to say. From the defects here stated, it is highly probable it will not be in great demand, unless its greater cheapness should induce tradesmen to speculate.

Having thus briefly described the principal varieties of ivory which are in the market at present, I shall notice some experiments which have been made with a view to account for the difference of character we find in them. I may here observe that the results arrived at are to be understood as approximations merely, the experiments not having been made with the degree of accuracy which strict analysis would require, but they are sufficiently near for the purpose.

In Hutton's Table of Specific Gravities, that of ivory is given at 1.825, and, by comparison, that of Indian ivory is 1.7, and that of Egyptian 1.54. This difference in the specific gravity would indicate a greater degree of porosity in the two latter than in the African, whose specific gravity is greatest. In order to test their absorbent power, equal weights of each were soaked in water five hours; the African had then gained three per cent., the others upwards of five per cent. in weight. Equal weights of each, which had been exposed to the air some weeks, and may be said to have been in their natural state of dryness, were then exposed to the heat of boiling water for five hours, when the African had lost five per cent. of its weight, and the others between three and four per cent.

From these experiments it appears that, in the ordinary state of the atmosphere, as to heat and moisture, African ivory contains more water than either of the other two varieties; that it absorbs water more slowly, and gives it off more slowly, when exposed to the same thermometric and hygrometric changes in the atmosphere. It is, therefore, less subject to expansion and contraction. This is to be understood only as it regards the ordinary changes in the atmosphere. A piece of ivory, of any description, if exposed, when newly cut or in a moist state, to a sudden elevation of temperature, would inevitably crack.

I have been furnished with the following analysis by Mr.

Sorby, the secretary of the Literary and Philosophical Society of Sheffield. The analysis was made chiefly with a view to ascertain the relative amount of animal matter contained in the three principal varieties of ivory, and the result was as follows:—In African ivory the proportion of animal to earthy matter was as 101.100, in the Indian as 76.100, and in the Egyptian as 70.100, the earthy matter being in all of them principally phosphate of lime.

Thus, though the composition, on the whole, is much the same, yet there is a sufficiently well marked difference in the ratios of the animal and earthy matter they respectively contain. The large amount of animal matter contained in the African ivory, taken in connexion with its greater density and its greater power of retaining water, may account for the semi-diaphanous appearance which it presents, and which forms so great a contrast with the Indian or Egyptian ivory.

Ivory dust is a substance which has long been used for making jelly, but, from the analysis I have just read, it appears that the strength of the jelly would depend on the ivory from whence the dust came. Equal weights of dust from African and Indian ivory were boiled for six hours in water, which was then freed from dust, and evaporated to dryness; the dust from the African ivory yielded seven per cent of hard gelatine; the dust from the Indian yielded nearly four per cent. of the same substance; so that to make a given quantity of jelly, double the quantity of dust would be required from Indian than from African ivory.

From the experiments and observations set forth in the foregoing remarks, it appears certain that when articles in ivory, whether intended for utility or ornament, are desired to retain their beauty for the longest period possible, it is advisable to have them made from African ivory, as it not only retains its colour, but, from its greater density and fineness of grain, it is capable of receiving finer impressions from the hand of the artist.

The date of the introduction of this material into the manufactures of this country is very uncertain, but it is highly probable that, for a long time, its use would be confined more to articles of ornament than of utility; and that, as the manner of working it became more familiar, the use of it would be extended to the ordinary articles of trade, of which the handles for the various kinds of cutlery consume the greatest quantity. Within the memory of persons now living, the workers in ivory in one of the staple trades of Sheffield did not amount to more than from ten to fifteen per cent. of the aggregate number in that trade; in the same trade at present they amount to upwards of forty per cent. Forty years ago, the late Mr. Wm. Batty, then agent for Mr. Lury, of Bristol, was the only dealer in ivory in Sheffield; at present there are five or six dealers in that material.

In 1830, according to Mr. M'Culloch, the average annual import of ivory was 180 tons; and it is the opinion of the best informed dealers that it continues to be about the same. Of this quantity about 60 tons are annually consumed in Sheffield, which, at an average price of £25 per cwt., amounts to £30,000, and about 500 persons are employed in the working of it up into articles of trade.

From the best information I can obtain from dealers in ivory, it appears that the number of tusks which make up the above weight is about 45,000; so that the average weight of each tusk is only 9 lbs.; but as many of them weigh from 60 to 100 lbs., a great number must be very small indeed. They are called ones, twos, threes, &c., up to forty, according to the number which make up the cwt.

The system which has gone on increasing during the last thirty years, of cheapening manufactured articles, is probably the cause of the greater demand for small tusks, which sell at a lower rate than the larger kinds. There is no way of reducing, to any extent, the cost of articles in ivory, except by reducing the quantity of ivory they contain. In this way the handles of table knives are reduced in length and thickness until they are mere shadows, and the tang by which the blade is fastened into the handle is covered only by a very thin skin of ivory, so that a very slight force or accession of heat is sufficient to break them. This attenuation of ivory handles in table knives is perhaps a cause why Indian ivory is more extensively used at present than formerly; the opacity of Indian ivory being so great, that a very thin film of it is sufficient to hide the tang of the blade, which, if the handle had been made of African ivory, might have been seen through it.

A friend of mine, who is a manufacturer in the United States, assured me that he had from a house in New York no less than eighty dozens of Sheffield-made knives with ivory handles, the whole of which were cracked and unsaleable, until my friend had re-handled them. On asking for an explanation of the cause, I found they had been made after the modern fashion—cheap; the handles had been attenuated, and, to effect a still further saving, they had been what is technically called "cut crossway," by which less waste is made in the ivory. If care had not been taken by the workman in making them, they would never have reached New York without being, the half of them at least, cracked. The additional ten degrees of heat of that city, however, accomplished what the care of the workman avoided. The cheap handles to which I have referred are generally cut from small tusks; large handles cannot be profitably cut from them.

I have once or twice alluded to the waste in the cutting of ivory, and it is a very important item in the cost of articles in ivory. From the best information I can obtain from persons who have had long experience in the cutting of ivory, the waste appears to vary from one-fifth to one-half, according to the articles into which it is cut; for example, a piece of ivory, one and a half inches square and one inch thick, may be cut into thirty slabs for miniatures, which, when ready for the painter, will measure just half an inch. A piece of the above thickness, but six inches square, may be cut into sixteen slabs that will measure no more than half an inch. In this case it is evident that half the material is wasted, which, in such articles, doubles the price of the ivory; and in all cases it is increased in proportion to the amount of waste.

There are few persons who have not seen, at some time, the beautiful designs executed in ivory, either by the eccentric lathe, or the hand of the artist. The same cause which prompted the cheapening of manufactured articles generally has produced attempts to imitate the productions of the hand in carving. Horn is pressed into a variety of forms by being first softened by heat, and then pressed between a pair of cut dies. Many attempts in this way with ivory have been made with partial success. But as softening by heat does not succeed with that material, recourse was had, I believe, to some chemical process. The specimens before you* were executed about thirty years ago, by Mr. Westwood, but, as the process discoloured the ivory, the articles never had an extensive sale. As Mr. Westwood's process was never made public, I am unable to describe it. The incompressibility of ivory is so great, that only a slight impression can be made upon it by the greatest force of a vice, and a blow or sufficient pressure makes a permanent stain upon it. Unless some process can be discovered that will soften ivory without discolouring it or decomposing it, or that does not make it tender and liable to crack, there is little hope that carving by hand will be superseded or rendered cheap.

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* Some specimens were shown at the meeting.

In the course of these observations I have stated, on the authority of a gentleman who was at some trouble to obtain the numbers, that the number of elephants' tusks imported annually was about 45,000, and as each animal produces only one pair, 22,500 elephants must be destroyed annually; but, if we suppose that one-fifth of the tusks are of large size, and the animals which produced them to have died from natural causes, there yet remain 18,000 to be destroyed to produce the annual importation which takes place. I have conversed with many persons who still believe that elephants shed their tusks as stags do their horns; but it is a fact, that these animals never shed any but the milk tusks, and these are said to be shed during the first or second year of the animal's growth. The origin of such a belief arises from the fact that some tusks, when they arrive in this country, have portions of muscular fibre adhering to them, and are designated as slaughtered tusks; thereby inferring that all tusks which are free from such matters have been shed. This opinion, like many others that are erroneous on subjects of natural history, can only be eradicated by diffusing more correct information amongst all classes of the community, which it is the duty, as it should be the pleasure, of every citizen to impart. Should the few brief and imperfect observations which have formed the subject of this paper assist, even in a small degree, to diffuse useful information, the end for which they were made will be answered.

ON THE GROWTH OF WHEAT IN RELATION TO CLIMATE AND TEMPERATURE. BY THE REV. WM. THORP.

It is the vegetation of a country which decides the social habits of a people, and determines the conditions according to which men gather into various societies. The inhabitants of the South Sea Islands enjoy, with little exertion, the splendid fruits of the banana, the bread fruit, and palm; while the people of the north laboriously cultivate the less fertile soil to secure their support by the scanty fruit of the cereals. In some parts of the Philippines the earth is so exuberantly fertile, that four crops per year are gathered in—two of rice, one of melon, and one of maize; while in the extreme north of Europe the husbandman is content with a miserable crop of barley. The bread-fruit tree in the tropics produces so abundant a crop, that three trees are quite sufficient to maintain a man for eight months. The great discoverer, Cook, says, "Whoever has planted ten bread-fruit trees, has fulfilled his duty to his own and succeeding generations, as completely and amply as an inhabitant of our rude clime, who, throughout his whole life, has ploughed during the region of winter, reaped in the heat of summer, and not only provided his present household with bread, but painfully saved some money for his children." On the table lands of the East India mountains, around the valleys of Cashmere and Nepaul, the people enjoy in summer the delicious fruits of the tropics, and in winter cultivate our northern cereals. Under such various conditions, by which the food of the people of different countries is raised, there must, naturally, be a corresponding variety in their social arrangements. Hence the great influence which the presence of a luxuriant vegetation has on the civilization and prosperity of nations.

But the vegetation of a country is determined by the heat and moisture which are received; for, if we examine this from the extreme north of Europe to the Torrid Zone, we find, as we change the latitude, a continual change in the physiognomy of the vegetation. And, again, if, in the Torrid Zone, we ascend from the level of the sea to the top of the highest mountains, which, there, often rise above the limits of perpetual snow, we find the same order of changes more or less defined. In ascending these mountains, the same climates are passed through which correspond to burning Africa, the temperate lands of Europe, and frozen of Spitzbergen; and as the elevation changes, so does the vegetation. The beautiful banana and the majestic palm in the tropics are not found above the height of 8,000 feet, but near the limit of perpetual snow are the grasses and other plants of Northern Europe.

The change of latitude is not, however, accompanied by a corresponding change in heat and moisture, owing to several causes which I shall shortly mention :—

1. Inland localities are colder than sea-coast ones of the same latitude. Thus, if we go towards the pole in the interior of the two great continents of either America or the Old World, it is found that the temperature decreases much more rapidly than in the interjacent seas. By Behring's Straits the voyager can only penetrate to the 70th degree of north latitude; by sailing along the American coast, through Baffin's Bay, he has reached the 77th degree of north latitude; while in the open sea, in the meridians of Norway and Sweden, it is easy to sail to Spitzbergen, which lies above the 81st degree of north latitude. The pole, therefore, is not the coldest point of the earth, but there are two poles of cold, one in the interior of each continent.

2. Winds and rain, or the absence of the latter, are other perturbing causes. In the north of Chili, on the coast of Bolivia, and in the south of Peru, are large tracts of country

where rain does not fall for years. The monsoons on the southern coasts of China, at Canton and Macao, produce so low a temperature that the leaves of plants are withered.

3. The east coasts of continents and isolated masses of land in the Northern Hemisphere are colder than the west coasts of the same latitudes.

Hence it becomes necessary, neglecting latitude, to connect places having the same mean annual temperature, by what are called isothermal lines; which lines, although, in the Tropics and near the Equator, they run parallel with the parallels of latitude, yet, in the Temperate Zone, run very irregularly; and, as a rule, in the interior of continents fall south of the latitude, and on the coasts rise north of it; while on the west coast they range to the south, and on the east coast rise to the north. The isothermal lines, therefore, indicate, with tolerable accuracy, the general vegetation of particular countries, but are of little use when we apply them to the growth of any particular plant, as of wheat; for the isothermal heat includes the heat of the whole year. But some plants are nearly at rest during winter, and the surrounding temperature has little influence on them; so that the mean temperature of different seasons, and of single months, is chiefly to be observed. For when plants unfold their leaves in spring, when they blossom in summer, and form their fruit in the autumn, every thing depends on their receiving, during these important periods, that degree of temperature which is appointed them by nature.

Thus barley, oats, and spelt are cultivated in the north of Europe at very high latitudes; at 69 deg. and even at 70 deg. north latitude, as at Lyngen, Alten, and on the frontiers of Norway, Sweden, and Russia; while on the plateau of Southern Peru, on the shores of the great lake of Titicaca, where is perpetual spring, and which is clothed with rich and beautiful vegetation, at a height of 12,000 feet, only oats and barley ripen; but wheat will not ripen, since the summer temperature never rises sufficiently high for this purpose. What this temperature is I shall inquire immediately.

So with the vine, which requires, in order to produce good wine, at least five months of a mean heat of 60 deg. Fahrenheit. If September and October have not this degree of heat, the wine is sour. For these reasons, therefore, that the temperature adapted for wheat is not indicated by latitude, nor by isothermal lines, but simply by a country having a certain number of days of a certain summer heat, or by the isotheral heat of Humboldt, let us examine its production in the three astronomical zones of the earth, viz., the Torrid, Temperate, and Arctic circles—for its cultivation fails north of 60 deg. These three zones, however, are too extensive, and include so many forms of vegetation, that Meyen has marked out smaller ones, and has divided each hemisphere into eight smaller zones.

To begin the description with the Torrid Zone, called, by Meyen, the Equatorial Zone.

The Equatorial Zone embraces, on both sides of the Equator, a zone of 15° of latitude, and a mean annual temperature of 80°, a heat which, in union with as high a degree of atmospherical moisture, calls forth an extraordinary profusion of vegetation. In several tropical countries wheat and the northern cereals are grown in winter, often in the very places where tropical fruits are grown during the wet summer months. Meyen saw this in the neighbourhood of Canton, and Royle mentions it for India, where, in some parts, in winter, the vegetation has a perfectly European aspect, and many species of true European genera make their appearance.

The low elevations at which wheat is grown in some parts of the tropics is remarkable; at Victoria, in the province of Caraccas, with 10° of north latitude, at the height only of

1,600 feet, and in the island of Cuba, in 20° north latitude, at still lower altitudes. Nay, in the isle of France, in 20° south latitude, it grows close to the sea shore. Similar instances have been observed in the island of Luçon, but here the mean heat is very much lowered by the prevailing monsoons. Wheat is cultivated at a great elevation on some of the uninterrupted plains of the Himalaya mountains, but probably higher on the plateau of Tacora, in the district of Cabul. It is cultivated in all parts of Chili, where there is sufficient water, from the sea, to a height of 5,200 feet, and the Chilian wheat is of excellent quality.

The extraordinary productiveness of wheat in some tropical countries has been stated by Humboldt. In Mexico he observed wheat plants with 40, 60, and even 70 stalks, the ears of which were almost equally well filled, and contained from 100 to 120 grains each. In the equatorial part of Mexico the produce is twenty-four-fold, and in plentiful years thirty-five-fold. Yet, in the tropical parts of America, the yield of maize is eight hundred fold where it thrives best, in a hot and damp climate; and one hundred-fold is looked upon as a poor crop of this grain in tropical countries. Yet in colder countries the yield is still smaller. In California it is seventy-fold.

In Mexico, (in the subtropical zone of Meyen,) between the parallels of 20° and 40° north latitude, the culture of wheat first begins at the height of 2,500 or 3,000 feet. At Vera Cruz and Acapulco, according to Humboldt, fields of wheat are first met with at the height of 3,600 feet, and ascend above 9,000 feet. On the plateau of Southern Peru, wheat fields, of extraordinary productiveness, lie at the altitude of 8,000 feet (Meyen); and at Cangallo, at the foot of the volcano of Arequippa, (south latitude 16°,) wheat succeeds well, even as high as 10,000 feet. In the North of Mexico the produce is seventeen-fold; in La Plata twelve-fold. In the middle temperate zones of Europe, viz., in France, wheat is cultivated to the height of 5,400 feet, and, according to De Candolle, rye is cultivated at 6,600 feet. The limit of corn culture on the Alps of Tyrol is at the height of 3,800 feet, in the Tyrolese Mountains 4,500 feet, and on Monte Rosa 5,880 feet.

In Hungary, Croatia, and Sclavonia, the average produce is from eight to ten fold. In Europe the cultivation of wheat ascends above 62° north latitude; indeed, Schouw gives 64° as its polar limit on the west side of the Scandinavian peninsula, but remarks, that it begins to be of importance below 60° north latitude; and in our northern latitude of Great Britain, which is approaching its polar limit, its cultivation is attended with great expense. The soil frequently requires draining, fallowing, manuring, drilling, weeding, to several of which operations the more southern countries are strangers; and, after all our endeavours, the yield depends upon the season in some manner not yet hitherto understood, or, as I before mentioned, on our reception of a certain number of days of a certain summer heat, that is, on the isothermal heat of Humboldt.

Mr. Lawes has satisfactorily proved, in some experiments detailed in the *Journal of the Royal Agricultural Society*, that season alone can make a difference of one-third in the quantity of the crop.

Upon the same field from whence seven unmanured crops had been taken, and no manure applied in any case, he found the difference in quantity in the years 1844, 1845, and 1846, to be as follows:—

	1844	1845	1846		
	Bushels.	Bushels.	B.	P.	Q.
Quantity of wheat per acre	16	23	17	3	3

So that the difference in quantity between the years 1844 and 1845 was as 16 to 23, or 7 bushels per acre, or nearly one-third.

But it has been remarked, that moisture has great influence. The quantity of rain which falls in any given locality is much the same, taken on an average; but the quantity, when compared with the general and equal distribution of that quantity throughout the several days and months of the year, is of very inferior consideration. A great quantity at the same time is rather hurtful than beneficial; whereas, those moderate but golden showers, which regularly fall on a soil calculated to receive them, are sources of fertility to most of our cultivated plants. Wheat, however, requires very little rain, since in Australia, where are produced the best wheats that come to England, at Adelaide, during those months which correspond with our months of May, June, July, and August, the fall is only 3.88 inches; while at London, during the same months, it is 8.49 inches, (more than twice as much); or there are 60 days of rain at the latter and 19 days at the former place. There is no doubt whatever that the temperature of our different summers, and especially during the months of May, June, July, and August, determines *the quality* of the grain. At Adelaide, in Australia, the mean temperature for these months is 79°, while the mean temperature for London is 60°. And, for the same reason, in spite of the wretched system of agriculture which prevails in Spain, Poland, and Sicily, the quality of their corn is superior to that which is produced by the skill and capital of the British farmer in ordinary years. The Dantzic red wheats, grown even in the Carse of Gowrie, have proved to be inferior to those grown in countries adjacent to the Baltic, showing, says Lawson, that the climate is not so well adapted to it. And the quality, as determined by weight, is of the first importance, for in some years the bushel of wheat will only yield 42 lbs.

of flour, while in other years it will yield 52 lbs.; making a difference in every acre, yielding 30 bushels, of 300 lbs. of flour, and this making more and better bread than an article of inferior quality.

In the experiment by Mr. Lawes, before referred to, he found a difference in the weight of the wheat per bushel, made by temperature, in the years 1845 and 1846, (on land unmanured and cropped successively for seven years), of 7¼ lbs; the weight being, in 1845, 56½ lbs., and in 1846 63¾ lbs. And, by an examination of the meteorological tables published by Mr. Luke Howard, it is found that the mean temperature of these four months varies in different years from 57°4′ to 63°; nearly 6° of Fahrenheit. But the manner in which the mean temperature of the month is calculated by meteorologists renders their registers nearly useless in this inquiry, since it is the custom in every month to take the highest and lowest temperatures that any night and day afford, and to call the mean of these extremes the mean temperature of the month. Hence, whatever may have been the heat of a certain number of days in each month, one cold night falsifies the whole, and reduces unnaturally the mean temperature. For example, during twenty-three days of the present month (August), the lowest temperature of any day is 61°; there are several days 66° and 68°, and six days above 70°; but one cold night of 37° reduces the mean to only 55°. But, surely, this cold night, or the cold nights during May, June, July, and August, do not injure wheat at all. A farmer never complains of the frosts in these months, while the maximum day temperatures only, and the prevalence of high temperatures, during these months, exert a beneficial influence upon the production of wheat, and, therefore, a register of day temperature is required. For, strictly and physiologically, it is by the action of light accompanying the heat that all nutrition in plants is effected;

the yellow or tithonic rays of the sunbeam have alone the power of fixing carbon. Heat itself acts a subordinate part, and immediately after sunset the leaves of plants no longer decompose the carbonic acid of the air, and they sink into a passive condition. The gaseous bodies brought from the ground by the roots percolate the delicate tissues, and escape into the atmosphere. Hence plants exhale carbonic acid at night and oxygen in the day time; and Dr. Draper, speaking of the carboniferous era, justly concludes:—"If plants have once grown in these latitudes with excessive luxuriance, and in short spaces of time have withdrawn large quantities of carbon from the air, this is a result which is connected not so much with internal or external temperature, as with variations in the brilliancy of light."* I have, therefore, no doubt that a register for these four months, of the temperature and quantity of light emitted, neglecting the cold nights, would at once afford an index of the growth and production of our wheat and other cereals. But as long as meteorologists confine their observations to the extremes of day and night, these are perfectly valueless in this agricultural inquiry.

In the year 1846, when Mr. Lawes produced from the exhausted field the weight of 63¾ lbs. per bushel, the mean temperature of May, June, July, and August, was 63°; and he concludes thus,—"If I could depend upon a constant climate in England, similar to that of 1846, I could produce annually 40 or 50 bushels of wheat upon an acre, with the same facility that I now produce 33 or 34; but as it is, that is, as the seasons are, were I to supply the proportion and quantity of mineral organic manures necessary to produce 50 bushels, in a wet and cold summer it would unduly develop the circulating condition of the plant, its vascular structure would be increased to an injurious extent, and the crop would be laid. Those who farm highly often experience this misfortune, and, consequently, dread a wet summer."

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* Chemistry of Plants, p. 96.

Making, therefore, allowance for bad seed times, which occasionally prevail; for frosts in winter, which constantly injure, more or less, the wheat upon some wet soils, and some varieties of wheat more than others, and also for wet seasons, I, therefore, conclude that, because the produce in the tropical and subtropical zones of the earth is in some parts enormous; that the wheats of Australia (12° to 39° S. lat.), with a mean temperature in the months of May, June, July, and August, of 79°, are of the finest possible descriptions; that the wheats of Spain, Poland, and Sicily are superior in quality to ours; that Mr. Lawes, with a mean temperature of 63°, in these four months grew wheat on a barren field weighing 63¾ lbs. per bushel, while with a temperature of 58°, he could only produce, under the same conditions, wheat weighing 56½ lbs, and with a temperature of 60°3″, that weighing 60¾ lbs., (these weights and temperatures being proportionate;) that the quality of our grain, and indirectly and generally, the quantity of our produce of wheat, are dependent upon an exalted temperature of the months in question. And hence

1. In all comparative chemical and agricultural experiments concerning the production of wheat, climate, or the temperature of the season, is an element to be taken into the calculation.

2. A knowledge of the precise effect (if it could be ascertained) which the climate of these four months has upon the produce of wheat, would enable the statesman and the farmer to predict, the one, the forthcoming value of his crops, and the other, the consequent condition of the country.

3. If the quality and quantity are determined by seasons, and the experiment of Mr. Lawes be even an approximation to the truth—that one season made a difference in quantity

of nearly one-third, and another a difference of 7¼ lbs. weight per bushel—the postulate of one of our well known writers on Political Economy, in his book, "On the Influence of the Corn Laws," must be received with great suspicion, "that extensive crops" are the result of cultivation stimulated by "high prices."

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FORTIETH MEETING, HELD IN THE LECTURE ROOM
OF THE HALIFAX PHILOSOPHICAL AND LITERARY
SOCIETY, ON THURSDAY, JUNE 6TH, 1850.

The Rev. WILLIAM TURNER, having been voted to the Chair, introduced the business of the meeting in an appropriate address, and regretted the unavoidable absence of the Venerable Archdeacon Musgrave, and John Waterhouse, Esq., F.R.S., the President of the Philosophical Society, both of whom took a warm interest in the proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. He had long watched with pleasure its operations—and noticed the various important communications which had been brought before its meetings, and he was glad to find that two subjects of such great interest as the Electric Light and Dia-Magnetism would be brought before them that day, and especially the former of these communications. He believed it was the intention of Mr. Dresser to describe a new and economic process for producing this extraordinary phenomenon, which he considered a great desideratum; as, in too many scientific discoveries, however apparently beneficial in their object, the expense involved was such as to place them beyond the reach of most persons, and it consequently acted as a check to their ever becoming generally useful to the public at large, which was the principal aim of scientific research. Upon the second subject, Dia-Magnetism, which might be considered in its infancy, much highly interesting and novel information might be expected.

The following gentlemen were proposed as Members of the Society:—

Dr. Paley, of Halifax.
Thomas Hodgson, Esq., of Halifax.
J. W. Child, Esq., of Halifax.
Mr. Thomas J. Pearsall, Agent to the Yorkshire Union of Mechanics' Institutes, Leeds.

The Chairman then called upon Mr. Dresser to read the first paper—

ON A NEW AND CHEAP VOLTAIC BATTERY FOR THE PRODUCTION OF THE ELECTRIC LIGHT. BY MR. CHRISTOPHER LEEFE DRESSER, OF LEEDS.*

Mr. Dresser described the different voltaic batteries previously in use, and the circumstances which led to the discovery of the suitability of gas carbon for voltaic purposes, and then proceeded with the following description of the peculiar substance used in his battery.

In the retorts used for the destructive distillation of coal to form carburetted hydrogen gas for illumination, after a certain period a deposit of a carbonaceous nature is formed on the iron, and, once commenced, proceeds with great rapidity, accumulating to such an extent as to close up part of the retort, and line the whole with a coating varying in thickness from that of writing paper to several inches. This carbonaceous matter, though a good conductor of heat, is not so good as the iron of the retort, consequently the process of distillation is impeded, and the waste of the heating power becomes at length so great as to compel the disuse of the retort. In many instances the iron of the retort is destroyed for a considerable space, and its place supplied by the carbon long before it is necessary to destroy the retort. From the continuous thickening of the deposit, it is evident that the process of deposition once commenced by the iron is continued by the red hot carbon.

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* The author will be happy to furnish the carbon, or in any way aid any one who may be inclined to repeat his experiments.

The property of red hot carbon to decompose hydro-carbons, was proved from the fact of a common broom having been accidentally thrown into one of the retorts, which, when charred by the heat, rapidly decomposed the gas, the carbon of which formed a singularly beautiful deposit on the slender stems of the broom, being deposited like branches of coral, hard, elastic, of considerable length, and very pure. The substance assumes a variety of forms and appearances, some of them very beautiful. The density and hardness varies also as considerably.

The form of the deposit appears to be either minute scales, like a section of a hollow sphere, or thin layers. The scales are deposited on each other till the whole takes the form of mammillar protuberances, sometimes of great metallic brilliancy, as specimen No. 1, having but little aggregation, and easily crumbled betwixt the fingers. This I believe to be pure carbon, though when heated sulphur is driven off, which appears to be mechanically mixed, and not chemically combined, for heat drives it off, and leaves the scales brilliant and unaltered in appearance.

Specimen No. 2 has the same form as No. 1, but more aggregated.

Specimen No. 3 has the same form, with considerable hardness.

Specimen No. 4 has the same type, but the mammillar protuberances are large, and apparently solid, but when exposed to a red heat for an hour, exhibits the same laminar form as the other. This specimen is very beautiful and singular.

Specimen No. 5. The mammillar form appears lost. The carbon has great hardness, equal to black marble, and the fracture is stony without any laminæ.

Specimen No. 6. Another appearance is presented of great metallic brilliancy, density, and hardness.

Specimen No. 7 is the same form as deposited on the charred broom, in needle-shaped ramifications, and when magnified is like a string of beads, very hard, elastic, and composed of pure carbon; at least I have been unable to detect any foreign substance, and there is no appearance of sulphur when heated.

Specimens Nos. 3, 4, 5, and 6, contain iron in a metallic state, but varying considerably in different specimens. No. 5 contains the greatest amount.

These forms of carbon will bear the most violent heat with very little waste. In my crucible furnace, urged with a large circular fan, raised far beyond a forge fire, it suffers but little waste, and gives an intense heat. Formed into crucibles, by a lump being cut hollow in a lathe, it is most valuable, standing where all others fail. The forms of this carbon, as shown in Nos. 5 and 6, are what I prefer in the voltaic battery, and may be obtained at any gas works at the most trifling cost, in plates of large size, and sufficiently thin to use in the square cells.

The most convenient form, and involving the smallest cost, also preferable in many respects, is to cut the carbon into sticks of about 1⅛ inch diameter, and 7 long, and use them with the nitric acid in round porous cells, the surrounding zinc cylinders being about three inches in diameter. The cutting of the carbon is accomplished with the greatest facility and certainty, by the machine of a marble cutter, at the small cost of 1¼d. each, and can easily be obtained from 6 to 18 inches long, and consequently be used with much longer porous cells.

The substance has but little porosity, but I prefer having the plates or cylinders about two inches above the top of the porous cell, as they will then remain in action for hours without affecting the connexions. The only precautions necessary are, after use, to immerse the plates in boiling water for a few minutes to abstract the acid, also to dry them well before a fire or in a stove, immediately previous to use; if these precautions are neglected the acid will absorb moisture from the air, and be always damp and affect the connexions. Often when in haste I place them on the fire, and sometimes heat them red, which in nowise deteriorates, but rather improves their action.

Having used the same plates and cylinders for a long time, no deterioration of their conducting power, nor any decomposition or alteration, has been observed. The connexion is made by soldering a strip of copper to the zinc, and pressing this very strongly against the carbon with a clamp. The more firmly the copper is pressed against the carbon the better will be the connexion. The copper should always be made bright where the contact with the carbon is made, and the surface of the carbon rubbed very smooth. The other parts of the carbon plate or prism may be left as taken from the retort or saw, its roughness increasing its acting surface.

Comparing these plates with plates of platinum of equal size, I can detect no difference, and from their cheapness and durability they will make a valuable addition to our voltaic apparatus. With a battery of 90 plates the voltaic light was of the most splendid description, 1¼ inch long, and very voluminous. My garden and a large field were brilliantly illuminated. The trees presented a very singular appearance; the leaves looked white instead of green.

Small print was easily read at a considerable distance, without any reflector behind the light. The cost of a battery of 100 pairs will be about £4, whilst one of equal power with platinum negatives would be £60 or £70.

The powers of the battery were tested by many brilliant experiments—as the ignition of great lengths of thin wire, the combustion of metals, the electric light, and the dispersion of that light by the prism.

In the course of the discussion which followed, Mr. Pearsall, in an interesting speech, alluded to the great importance which might accrue to the public, and especially in saving the lives of mariners, if the adoption of this magnificent discovery were brought into use in lighthouses, or sent out in steam vessels on particular occasions, as foggy weather, &c., to guide ships on dangerous parts of the coast; and hoped that no argument of such a paltry or disgraceful character as expense would interfere to prevent so benevolent a project being carried out.

Mr. W. S. Ward supported the proposal of Mr. Pearsall, with additional suggestions as to its applicability, and the means of recognising the different lighthouse stations, by the *number* of lights employed, &c.; also on the comparative cost per hour of a light such as Mr. Dresser had exhibited, as weighed off by a galvanometer in the room; and showed the fallacy of supposing this light, however beautiful, would ever supersede the ordinary gas for shops, streets, &c.

ON SOME PHENOMENA OF DIA-MAGNETISM, WITH EXPERIMENTS. BY WILLIAM SYKES WARD, ESQ., OF LEEDS.

In the course of some experiments, in which I was desirous of exhibiting the principal phenomena of Dia-Magnetism, described by Dr. Faraday in the transactions of the Royal Society, I was at first surprised at obtaining different results from those published; many metals which, according to Dr. Faraday, had appeared to take an equatorial position between the poles of the magnet, assumed the axial position as magnetic bodies. I soon observed that the nature or direction of the action upon many metals varied with the intensity of the magnetic force, and I found that such effects were in accordance with the observations of Professor Plucker. On this he appears to have correctly founded the hypothesis, that the dia-magnetic force increases more rapidly than the magnetic in relation to the power of the exciting magnet.

Not being aware how far Professor Plucker may have extended his researches to the phenomena of the magnetic and dia-magnetic forces developed in pure metals, I conceived that the inquiry, how far such forces might be co-existent in the same metal, might lead to interesting results. In pursuing such investigations other phenomena presented themselves to me; and as these in some respects depend upon the power of the magnet employed, I will describe the apparatus with which the experiments were conducted. My electro magnet is composed of a bar of soft iron 1½ inches in diameter, 11 lbs. in weight, and about 20 inches in length, bent into a horse shoe form. It is covered in the usual manner with about 120 yards of insulated copper wire, No. 12, Birmingham wire guage, connected in one length. The poles of the magnet are about 3½ inches apart, and are furnished with polar pieces, the distance of which can be varied from about one-tenth to two inches, and regulated by set screws. The polar pieces are tapered so as to present plane faces in the form of parallelograms, which are about 0.3 inches in breadth, and 0.2 inches in depth. I generally employ four pairs of

Grove's elements, of which the platina is 2½ inches wide, and immersed about four inches in nitric acid, in good flat porous cells. The quantity of current which the four cells cause to circulate through the magnet is generally equal to about 130 grains of zinc dissolved in each cell per hour. The mode of suspension was by a fibre of silk suspended within a glass cylinder, placed on a kind of stool above the magnet, which is used in an upright position.

In making use of a small magnet I found it advantageous to experiment on correspondently small pieces of metal, of about the size and weight of a fourpenny piece, (or about five-eighths of an inch in diameter, and 30 grains in weight. I suspended such pieces of metal as were readily pierced, by means of a hole drilled through the upper edge, and through which a copper wire, one-hundredth part of an inch in diameter, was fastened, with a little hook at the other end of the wire, to attach it to a ring at the end of the silk fibre.

Such arrangement is abundantly sufficient for the exhibition of the effects I am about to describe, and indeed with it I first noticed several phenomena which had escaped my attention when using a much larger magnet.

Most of the experiments I am about to describe were well exhibited by another magnet, of which the core was only six-eighths of an inch in diameter, and two lbs. weight, of the horse shoe form, and having about 30 yards of No. 18 wire coiled upon it, and having similar polar pieces. This magnet was excited by three small pairs of Grove's battery, with circular cells of the ordinary construction, having platina strips half an inch broad and immersed about three inches in nitric acid.

In submitting the metals—gold, silver, lead, tin, zinc, and cadmium, to the action of the magnet when excited by an electric current of only moderate force, for instance, when only one cell of the battery was employed, the current through the magnet being equal to about 30 grains of zinc per hour, or when the polar pieces were at a distance of not less than one inch, the last mentioned metals took the axial position, pointing in the same direction in which a piece of platina would have done. But when the battery power was increased, and the poles brought nearer together, instead of the disc of metal being more strongly attracted, it became less sensible to either attraction or repulsion, and was very sluggish in its motions, retaining for some time any position in which it was placed; and although it did not remain stationary, as mentioned by Dr. Faraday with regard to copper, yet it moved to the axial position very gradually, and without the oscillation it exhibited when the magnet was either more or less powerfully excited. But when the magnet was both well excited and the polar pieces brought within a quarter of an inch of each other, most of the before-mentioned metals took a decidedly equatorial position, and were repelled as dia-magnetics, the sluggishness nearly disappeared, and the disc vibrated about the equatorial position as antimony or bismuth would have done. I shall afterwards more particularly mention the order in which such changes appeared to take place with various metals.

As I experienced much difficulty in procuring specimens of metals perfectly free from any admixture of iron, I at first doubted whether the attraction of the metal did not depend on the presence of a minute portion of iron, and that the repulsion afterwards exhibited was due to the peculiar condition of the metal; and I found that in some specimens of the metals which readily exhibited the presence of a small quantity of iron by the ordinary chemical tests, the magnetic state was much more decided than with purer specimens. But as some of the metals were as free from iron as I believe it possible to obtain them, I think the phenomena of the variable magnetic and dia-magnetic states of metals may be safely considered as being independent of the presence of iron or other constantly magnetic bodies.

In experimenting upon the metals—gold, silver, copper, lead, and zinc, my attention was particularly drawn to the phenomena described by Dr. Faraday, and by him called "revulsion," and I found that the form of small flat discs was a particularly convenient one for exhibiting these. Dr. Faraday noticed the phenomena of revulsion, particularly in copper; I, however, found that it is exhibited in nearly all metals which are less magnetic than platinum, or less dia-magnetic than antimony. I noticed that the direction of the revulsive motion is different in magnetic and in dia-magnetic metals. I adopt Dr. Faraday's term revulsion, and I call the revulsion repulsive when the disc subjected to experiment is repelled on breaking circuit; and attractive when the disc is attracted under the like circumstances. I also noticed that in the metals, whether pure or compound, which passed from the magnetic to the dia-magnetic state, the direction of the revulsion also changed. That such a body, exhibiting attraction as magnetic, was vigorously attracted through a small space on making battery contact; and as vigorously repelled on breaking the circuit. That when the same body, by increasing the battery power, or more conveniently by approximating the polar pieces, was made to pass into the dia-magnetic state, the directions of such revulsive motions changed—that on making contact the metal was repelled; and that on breaking contact it was attracted: I found motions were in some cases to be relied on, as pointing out the magnetic and dia-magnetic state of the metal, when the steady pointing of the piece axially or equatorially could not be observed. The revulsive motion not being exhibited by the disc of metal when it had assumed a position either strictly axial or strictly equatorial, in order that the phenomena should be fully developed, I found it necessary to prevent the disc from assuming such positions. With metals tending to the axial position this was easily effected, by closing the polar pieces so that the disc could not pass to the axial position, being stopped by the polar pieces themselves; but in experimenting with some metals in which the revulsive action is only manifested in a slight degree,—for example, with palladium,—some care is needful in ascertaining whether revulsion takes place or not, for if the disc of metal be allowed to touch the polar pieces, the vibratory action of the magnet appears not unlikely to communicate itself to the disc, thus producing the appearance of revulsion; therefore, in such experiments I found it convenient to use a steady support, by which the disc under examination is prevented going to the axial position. Such a support is also very useful in preventing a metal, affected dia-magnetically, from taking the exact equatorial position; but when a support is used, the motions require to be observed very carefully, for the disc appears to be moved from the position in which it would hang when not affected by the magnetic or dia-magnetic force, and to move, as though revulsively, by the mere action of gravitation. But on carefully noticing the motion, it may be observed whether it be more rapid than that due to gravitation alone.

The changes from the magnetic to the dia-magnetic state are, perhaps, most decidedly exhibited by pure zinc or pure lead. When a very considerable magnetic power is applied to these metals, either by increasing the power of the battery, or by approximating the polar pieces, instead of attraction, as magnetic bodies, they show repulsion, as dia-magnetics; and I found that after this change of condition the phenomena of revulsion were exhibited as before, but in a reverse direction; and that when the magnetic force was sufficiently energetic, repulsion took place on making contact, followed by attraction on breaking contact. In experimenting upon lead and zinc, if the support be moved to one side, so that one side of the disc just touch the flat end of the polar piece, the disc is repelled on making contact, and is held at a small distance from the polar piece, whilst the current is continued; but on breaking contact it is briskly attracted by the polar piece. To produce the last mentioned effects in a decided manner, although the effect may be observed with one polar piece, yet it is advisable to have the two close together, as the magnetic force does not appear to be sufficiently concentrated in the one piece if the other be not approximated to it.

It might be supposed that as gold, silver, copper, lead, tin, zinc, and cadmium, take an axial position when the polar pieces are distant, and an equatorial one when they are close, that neutral points would be found at which neither attraction nor repulsion would take place. I found that this happened with lead; but with gold, and particularly with zinc, the disc was attracted when contact was made, but afterwards, during a few seconds, it slowly moved to the equatorial position; moving extremely sluggishly, in the manner particularly noticed by Dr. Faraday with regard to copper. But, although during this sluggish state, the disc appeared to be little affected by any directive force towards the axial or equatorial position, yet, on breaking battery contact, the revulsive force was most strongly developed. And it was very remarkable that if the contact were broken before the disc had assumed an equatorial position, the revulsion was from the nearest polar piece, tending to make the disc revolve. But, on the contrary, if the circuit were broken after the disc had assumed an equatorial position, the whole disc was swung towards the polar piece to which it happened to be the nearest, and with sufficient force to move the whole disc as a pendulum through an arc of two or three degrees; so that although the magnetic and dia-magnetic forces seemed as if balanced or neutralised, yet the revulsive forces corresponding with these were strongly manifested in either direction, as the case might be. It appeared always necessary that some time (about one second) should elapse before the magnet induced the dia-magnetic state; but I did not, in any instance, observe the disc to be in a neutral state as regarded the revulsion.

The motion communicated to the disc by the attractive revulsion is, however, very different from that exhibited by the repulsive revulsion. The latter always tended to make the disc revolve on its centre of suspension, both the edges being repelled from the polar pieces to which they were nearest; but the attractive revulsion caused the entire disc to move towards the polar piece to which it was nearest, without exhibiting any tendency to make the disc revolve.

For the purpose of ascertaining in what order different metals were affected magnetically and dia-magnetically, I instituted the following experiments; in which I made use of the eleven pound magnet, excited by the four cells of Grove's battery, as before-mentioned. Platinum and palladium were procured from sources which I could not trace, and, as had been observed by Dr. Faraday, these metals took the axial position, with weak or strong powers, or with the polar pieces distant or close; and the revulsion, although by no means so strongly developed as with other metals, was repulsive on breaking contact. Antimony and bismuth were from common commercial specimens, and had been cast after being melted in an iron ladle; nevertheless they were decidedly dia-magnetic, even with very slight powers, and with the polar pieces distant: thus negativing the supposed need for great care to insure perfect freedom from iron, at least as regards these metals. Mercury was also found dia-magnetic under any power which would at all affect it in this respect. It did not distinctly exhibit any revulsion. Of arsenic I had not such a specimen as enables me to speak decidedly. It appeared to be magnetic with the poles distant, dia-magnetic with the poles close. The structure was so decidedly crystalline that I could not ascertain whether the change of position was not due to the varying ratio of the magne-crystallic force. The four last mentioned metals did not show any decided revulsion when the circuit was broken, but if any took place it was that of attraction, but it was too slight to be relied on; for the dia-magnetic action so repelled the body from the adjacent pole, that when such action ceased, the disc under trial would swing as a pendulum, under the mere action of gravitation. On very careful examination, however, it appeared that the motion, under such circumstances, was somewhat quicker than was due to gravitation alone.

The specimen of zinc which I selected for the purpose of these experiments was reputed pure, having been prepared for use in Marsh's apparatus, and had not been hammered or rolled. It was much less magnetic than other specimens of the ordinary sheet zinc. The polar pieces being adjusted at a distance of three quarters of an inch, (0.75,) the piece of zinc was attracted when contact was first made, and afterwards appeared sluggishly to retain any position in which it might be placed, but, nevertheless, slowly moved to the equatorial position; that is, it appeared magnetic at the first contact, but afterwards gradually became dia-magnetic. If the circuit were broken before the disc of zinc had decidedly assumed the equatorial position, the revulsion was strongly repulsive; but the circuit being broken after the disc had assumed the equatorial position, or nearly so, the disc was strongly attracted: and if the disc were rather nearer to one polar piece than the other, instead of the disc tending to revolve on its centre of suspension, as in the revulsion from the magnetic state, it was moved entirely toward the nearer polar piece, the whole mass being decidedly attracted.

Gold.—The specimen used was a quarter-guinea piece; this was decidedly less inclined to become magnetic than zinc, when the polar pieces were at 0.75.

The piece was magnetic at the first contact, afterwards very sluggish, and only slightly sensible to either attraction or repulsion. At 0.38, gold exhibited the like phenomena as zinc at 0.75, and also at shorter distances.

The like phenomena were exhibited by zinc, as the polar pieces were progressively brought nearer each other, as afterwards mentioned. The change from the magnetic to the dia-magnetic state, and also in the direction of the revulsive motion on breaking circuit, was most decidedly shown when the polar pieces were at a distance of 0.37.

I procured *Lead* by voltaic deposition from nitrate of lead, the metal thus obtained was redissolved in pure nitric acid, and again electrolitically deposited, then fused on glass, with the addition of a little tallow as a flux; the piece thus obtained appeared decidedly magnetic at 0.75; was very sluggish at 0.56: took a diagonal position, with the edges of the disc nearly touching the polar pieces, but still sensibly separated. With closer adjustments of the polar pieces, lead behaved as the zinc had done at greater distances.

Cadmium—(the purity of this was not tested, but it was reputed to be pure)—continued to take the axial position when the polar pieces were approached to 0.29, but its motions then became very sluggish; and at 0.15, after being first attracted, took a decidedly equatorial position.

Tin—(this was deposited, electrolitically, from a solution of protochloride)—continued to tend towards the axial position, or to be attracted till the polar pieces were approached to within 0.15; the motions were then very sluggish, but exhibited signs of being attracted on breaking circuit.

Silver and Copper continued to be attracted, the polar pieces being at 0.15. The silver was prepared by reducing precipitated chloride of silver by carbonate of potash, in a small crucible of pipe clay. The copper was deposited from sulphate of copper by the electrotype process.

The polar pieces being closed to within 0.1, the zinc and gold were yet attracted at the first completion of the voltaic circuit, but afterwards appeared as though floating between the two surfaces: but lead at once took the equatorial position, without experiencing any attraction. Tin and cadmium were also repelled after the first contact. Copper and silver continued to be attracted.

The experiments with the polar pieces so close as 0.1, are not altogether to be relied on, as regards the revulsive movements, for the lateral motions hereafter mentioned took place so decidely as to render the other movements very difficult of observation.

One of the polar pieces being altogether removed, and the discs being hung at a distance of about a millimetre from the other polar piece, and the arrangement maintained as before in other respects, platina was attracted, and no revulsion exhibited. Palladium was very slightly repelled on completing the circuit, and then attracted; but on breaking the circuit was revulsively repelled, though so slightly that the motion was only just perceptible.

Zinc, gold, and lead were instantly repelled on completing circuit; continued to be repelled, though in a somewhat less degree, whilst the circuit was continued; and were decidedly attracted when the circuit was broken. Silver, copper, cadmium, and tin were repelled on completing circuit, but one side of the disc touched the polar piece, the other side being repelled; and on breaking circuit the side of the disc which had been repelled was strongly attracted. Bismuth and antimony were strongly repelled from a single pole, but no decided attraction was apparent on breaking circuit; the motion not being distinguishable from the effect of gravitation, which caused the disc to swing towards the polar piece, after the force which repelled it had ceased.

When the polar pieces are very close, that is, about 0.25 to 0.1 apart, and the disc of metal is so suspended that one half of it is without, and the other half within, or between the polar pieces, another series of phenomena present themselves. If the metal be amongst those classed as magnetic, or be magnetically affected by the power employed, it is, of course, attracted, and clings to one or other of the polar pieces, after the first motion, to be hereafter noticed, has subsided. If the metal be dia-magnetic it is repelled, and, in many instances, driven entirely out from between the polar pieces. At the instant of the completion of the voltaic circuit, the disc of metal moves transversely, as a pendulum, with a tendency to pass outwards from between the polar pieces; and on breaking circuit the disc moves transversely, but in the reverse direction, tending to pass within the polar pieces. Such motions are very remarkable, in that the direction of them is alike in all metals which do not become so strongly attracted by the magnetic influence as to cling firmly to one of the polar pieces. Thus they are exhibited in the same direction with platinum and palladium as with antimony and bismuth. But they are exhibited with greater force by those metals which decidedly show revulsion. Silver and copper discs are so strongly drawn within the polar pieces on breaking circuit, as frequently to pass out at the other side of the polar pieces.

As it appeared to me that these transverse motions were, to a considerable extent, independent of the other phenomena of dia-magnetism, it occurred that they were produced by secondary electrical currents, induced in the disc of metal; and to ascertain whether this could be demonstrated experimentally, I took a piece of copper wire, about one-fiftieth of an inch in thickness, and folded it so as to make a flat spiral of the size of the discs previously employed, and of which the folds did not touch each other. On suspending the insulated spiral between the polar pieces it did not exhibit the transverse motions, nor the short and quick movement on completing circuit; or the revulsive motions on breaking circuit. But on constructing another spiral similar to that before-mentioned in all respects, excepting that part of the wire from the centre was prolonged, and put into connexion with the other end, forming the external fold, the motions, both revulsive and transverse, were exhibited in like manner as if a disc had been employed, though more feebly, as might be expected, inasmuch as any electrical current would have to pass through a considerable length of wire, and would meet with much greater resistance than it would have done in the disc.

Several discs of copper wire, folded in various manners, were tried with the like results; for if the folds were insulated, and the ends not in contact, so as to form a circuit, revulsive motions were not exhibited; but if the two ends were connected, then the revulsive motions, attractive or repulsive, according to the circumstances, or the lateral motions, were exhibited as before-mentioned.

Most of the before-mentioned experiments were varied by using an electropeter, which enabled me very rapidly to discontinue and renew, and also to change the direction of the current exciting the electro-magnet; but without obtaining any results worthy of particular description, in addition to those already stated; as reversing the voltaic current did not produce effects on the suspended disc essentially different from what would have been exhibited by the discontinuance and immediate renewal of the current in the same direction.

The arrangements of the battery were also varied by using six pairs of elements of zinc and platinised silver, each having about 1.5 inches acting surface, in addition to the four cells of nitric acid battery, so arranged that when the more powerful current of the latter was discontinued, a comparatively feeble current continued in some instances in the same, and at other times in the reverse direction. These arrangements did not, however, give any particular results, further than that the effects, on discontinuing the powerful current, were perhaps somewhat diminished; showing that the freedom of the electro-magnet from residual magnetism is only of slight importance in dia-magnetic experiments, and that the motions produced on the suspended disc are due to the exaltation or depression of the magnetic force, and not to its entire cessation.

I also repeated some of the experiments of Professor Oerstead, an account of which was recently published in the *Philosophical Magazine* for 1849, vol. xxxiv. p. 81, in which he pointed out that when the polar pieces are brought very closely together, and a small bar of dia-magnetic substance is suspended immediately over the space separating the polar pieces, the suspended bar may assume either the equatorial or the axial direction. I found this the case with bars of various metals; and that these would take the apparently reverse position—that is, axial for equatorial, or the equatorial for axial—instead of that which they would have taken if suspended between the faces of the polar pieces. If I do not misunderstand Professor Oerstead's deductions from these phenomena, he seems to have supposed that under such circumstances the metal acquired a different state, or a different direction of polarity in regard to magnetism, when suspended above, than between the polar pieces. It did not appear to me that this was the case, but that all apparent anomalies might be most easily explained by considering the direction and distribution of the magnetic forces exhibited by the polar pieces when distant and when close. On examining the polar pieces when separated about half an inch, by means of a very small and delicately-suspended disc of metal, either magnetic or dia-magnetic, it is ascertained that the magnetic force is most strongly developed, as though upon the exterior of such parts of the polar pieces as are opposed to each other; and that with polar pieces having plane surfaces, similar to those employed in these experiments, the magnetic force is more strongly developed at the corners of the opposed parallelograms. Thus it appears that when the polar pieces are distant, the line about which the disposition of the magnetic force is a maximum, is the axial line joining the two poles; but that when the polar pieces are brought very closely together, the greatest intensity of the magnetic forces is upon the two parallel lines on the upper edges of the opposed faces; and the two parallel lines being very near each other, may be considered as a single line in regard to their action upon the suspended piece of metal; and it may also be observed that the forces are greater towards the extremities than at the middle of such lines, so that the direction of the magnetic force becomes virtually equatorial instead of axial, in regard to a bar of metal suspended immediately above the space separating the polar pieces.

In experimenting with small bars of lead, the length of which was three-quarters of an inch, breadth one-tenth, and thickness one-twentieth, and suspended above instead of between the polar pieces, I found that the like changes from the magnetic to the dia-magnetic states, and also the like revulsive motions, were exhibited, as when the metals were suspended between the polar pieces, due consideration being given to the change in the direction of the distribution of the magnetic forces, when the polar pieces were made to approach very closely to each other.

Whenever a series of facts are discovered which are not readily explicable in accordance with generally received theories, we may hope to acquire some useful correction of such theories, by either extending their applications to the newly discovered facts, or by altogether remodelling such parts of the general theory as may be inconsistent or inapplicable. In this point of view I conceive that all facts relating to dia-magnetism are particularly interesting, and may reasonably be expected to lead to an increased knowledge of the physical properties of matter. I hope this part of the subject will be pursued by those most able to do so; but as I have, in the course of my experiments, been unable to explain the phenomena according to the theory of Ampere, and have, therefore, attempted to discover the laws on which the observed phenomena were dependant, I will endeavour to communicate the ideas which then occurred to me. I feel, however, the more diffidence on this subject, as my opinions are not quite in accordance with those generally received in regard to electro-magnetism.

According to the theory of Ampere, the magnetic condition is induced by the action of electric currents, circulating around the particles of matter; and it has been shown that both permanent and electro-magnets, under certain conditions, induce electrical currents. The circumstances under which a magnet or an electric current induces another current, have been very fully investigated, but we do not find any instance in which the direction of the induced current is affected by the nature of the matter in which the induction takes place. If it were only necessary to account for those magnetic phenomena in which the matter subjected to electrical or magnetic force becomes affected by such polarity that it is attracted by the pole of the magnet to which it is opposed, we might have no great difficulty in the general application of Ampere's theory; for we may easily conceive that currents circulating around the poles of an electro-magnet induce other currents in a neighbouring mass of iron, under the influence of which the latter is affected by such induced electrical currents as to be attracted by the electro-magnet; but I am not aware of any extension of Ampere's theory by which it can be explained how it happens that when, in lieu of the piece of iron a piece of bismuth is substituted, the latter is repelled, instead of being attracted.

The theory of Ampere may be applied to explain the magnetic or dia-magnetic state of some bodies, for instance, platinum and bismuth, by supposing that in the platinum a current is induced in one direction, and in the bismuth in the opposite; but with regard to the phenomena exhibited by lead, the difficulty is much greater. We may suppose that the magnetic condition of lead is caused by a current in one direction, and (passing over the difficulty of accounting why a feeble magnetic force should induce a current in one direction, and a greater degree of magnetic force a current in another direction) that the dia-magnetic condition is caused by a current in the contrary direction to the assumed current in the magnet. But we have the intermediate state, not neutral, but sluggish (for a more elegant term has not yet been suggested.) I cannot conceive any manner in which we may account for such assumption of the sluggish state according to Ampere's theory, unless we suppose two currents in opposite directions in the same piece of metal, and at the same time; a supposition which is contrary to all observed phenomena or laws of electric currents. We should, nevertheless, have some difficulty in explaining the effects produced, for under whatever circumstances we have hitherto observed the production of such currents, we find that they are transient, and only continue during such time as the inducing force is either increasing or diminishing. We find, on the contrary, that the magnetic force does not in general rise to its maximum until after the lapse of a longer period of time than an electric current, induced under similar circumstances, would have continued. This consideration becomes still more forcible in regarding the phenomena exhibited by zinc, under the influence of forces which are little more than sufficient to render it dia-magnetic. The zinc is at first attracted as magnetic, but slowly becomes dia-magnetic, appearing to pass through an intermediate state, in which it appears very little sensible to either attraction or repulsion. We have also to consider the phenomena of revulsion, which might be explained by the hypothesis of induced currents, if the revulsion always took place in the like manner and direction. The revulsion is sometimes attractive, and sometimes repulsive; if, therefore, these phenomena be due to induced electrical currents, such currents must be in different directions. I have, however, pointed out that the phenomena of revulsion are intimately connected with electrical currents, as the revulsive effects are not exhibited with the insulated disc of wire, in which the completion of a circuit is prevented. On these, and similar considerations, I have doubted whether in any case an electric current directly induces a current in a parallel conductor, and formed an hypothesis, by which I conceive many of the phenomena, otherwise discordant, may be accounted for.

The full development of my hypothesis might lead to the introduction of some ideas, in relation to the constitution of matter, foreign to the subject of this communication: I must, therefore, assume certain positions which admit of considerable doubt.

I will assume that matter is composed of ponderable atoms not in absolute contact, but separated by intervening space, or by imponderable matter; and I consider it unnecessary at present to determine, or even to consider, whether the space intervening between the ponderable particles be occupied by an imponderable element, as caloric, by an ether, as assumed in some of the theories of light, by vibration, as assumed in other theories, or by any other manner or form of mere force. Such compound constitution of matter is necessary, in order to admit of any explanation in what manner matter may become affected by any kind of polarity.

I will also assume that when matter becomes polar its molecular condition is disturbed; that when the molecular constitution of a body is disturbed electricity is developed, though the exhibition of any electrical phenomena will depend on the circumstances permitting the establishment of an electric circuit, as certain conditions of matter will, in many cases, so permit the return of the electricity through a short circuit within the matter in which it is developed, that no external effects can be observed.

I also assume, as a correlative circumstance, that an electric current produces molecular disturbances, not only in the matter conducting the current, but also in the contiguous matter, whether conductor or non-conductor; that the disturbance of the particles not engaged in the actual conduction of the current is a kind of polarity continuing during the uniform transmission of the current through the adjacent conductor. I consider that such polarity either is or is not accompanied by a molecular disturbance of the particles of the body; and also that when such polarity ceases, another molecular disturbance again takes place, the particles returning to their normal condition. Such molecular disturbances, according to my hypothesis, occasion electrical currents, if they occur in bodies favouring the circulation of such currents, that is, in conductors. Thus I conceive that I can explain how a current, at the moment it is established, or during such period as its force is increasing, induces a current in an adjacent conductor; not by direct induction, for direct induction should produce a continuing current, but that the particles being polarised, or being subjected to a molecular disturbance, induce a secondary current during such period as the disturbance is being effected; and that the molecular disturbance having attained a maximum, the secondary current ceases; that when the primary current ceases or declines, the polarised atoms regain their former condition, such change being also in the nature of a molecular disturbance, which induces a secondary current in the opposite direction to that first induced.

To apply such hypothesis to the explanation of magnetic phenomena, it may be assumed that such polarity is produced; that in each particle the ponderable atoms are unequally distributed with regard to the imponderable, (still disregarding the consideration whether such imponderable be material, or be vibratory, or a mere condition of force), and that such polarity is the cause of attraction or repulsion according to the direction in which such polarised atoms, in two bodies, are presented to each other.

In electro-magnets, I conceive that such molecular disturbance or polarity is in some manner disturbed by the influence of the neighbouring electric currents; but our knowledge of the molecular constitution of matter is as yet much too limited to admit even a supposition being formed as to the precise manner. In permanent magnets of hard steel, I think that a similar polarity is effected by the process, whatever it may be, by which the magnetism is induced; that such polarity is retained for an indefinite period, as the hardness of the material prevents the polarised particles returning to their normal condition.

We may conceive that a body (A) affected by magnetic polarity, may affect an adjacent body (B), producing a similar polarity, by arranging the particles of B in like manner as those of A as regards polar direction; that of the particles of A, the ponderable matter is distributed in one direction, the imponderable in another; but on substituting another body (C) for B, the arrangement of particles may be so different, in that the imponderable is more attracted, that the imponderable B will exhibit phenomena as a magnetic bar dia-magnetic; and we may conceive, in accordance with Professor Plucker's law, that the effect of the dia-magnetic force on the attraction causing it, affects the ponderable and imponderable atoms of matter in a different ratio; that a certain development of magnetic force attracts the ponderable elements more than the imponderable, producing magnetic polarity; that a higher development of magnetic force attracts the imponderable more than the ponderable, producing dia-magnetic polarity; that in an intermediate state both the ponderable and imponderable atoms are attracted so equally, that neither magnetic nor dia-magnetic polarity is produced; but, nevertheless, such molecular disturbance is caused, that powerful revulsive currents are developed on the discontinuance of such affection of the atoms.

Having considered how the magnetic and dia-magnetic condition of matter may be accounted for, the revulsive motions require considerable attention. These cannot, in any manner which I can conceive, be explained on any hypothesis, either of molecular action, independently of electric currents, or of electric currents directly induced by the magnetic force. If the revulsive motions were supposed to arise on the ceasing of the molecular disturbance, under such conditions that on the ceasing of the constrained molecular condition, the atoms, by a species of libration, spring into the contrary arrangement, passing beyond the normal condition, and thus that magnetic action is succeeded by temporary dia-magnetic repulsion, and dia-magnetic action is succeeded by temporary magnetic attraction, we have, in addition to many other objections, the important one that the force exhibited by the revulsion is not in proportion to the force supposed to originate it; for, as appears from the before-described experiments, when the magnetic force is considerable, as in palladium, the revulsive force is very slight; and when the magnetic force is slight, as in zinc, the revulsive force is comparatively very considerable. I have also shown by the experiments with spirals of copper wire, that the phenomena of revulsion and of the transverse motions are closely connected with the conduction of electric currents. We do not perceive these motions when a complete circuit is not afforded for the electric current, nor have I been able to observe them in bodies of inferior conducting properties to the metals.

The conducting power of the metal may, to some extent, affect the amount of revulsive force exhibited; but the property of revulsion clearly does not depend on this, for platina is a much better conductor of electricity than lead, and in platina we have little, if any, revulsion, whilst in lead it is strongly exhibited; and in copper, which is considered to be the best known conductor, we have the revulsion very strongly exhibited. We cannot account for the revulsive motions on the generally received hypothesis of induced secondary currents, for, as I have before pointed out with regard to magnetism and dia-magnetism, such currents would only account for revulsion in one direction.

I conceive that the revulsive motions are caused by the magnetic affection of the piece of metal induced by electric currents, which currents are produced in the metal on the subsidence of the molecular disturbance, previously caused therein. It would be difficult to say how, on the determination of the attractive polar condition of a piece of metal affected magnetically, a current should be produced which should reverse the polarity, and develope a greater force in the opposite direction; but it is not the strictly magnetic polarity which precedes the repulsive revulsion, but that molecular condition which takes place in the intermediate or sluggish state, that, as I conceive, is the immediate cause of the induction of the current. Thus with platina and palladium we have little, if any, revulsion exhibited, these being affected only magnetically, and not passing into the intermediate state; whilst with all the metals which are magnetic under one amount of force, and become dia-magnetic under an increase of force, and all of which pass through the intermediate or sluggish state, we have the revulsive motion strongly developed. It must also be observed that in the metals, antimony and bismuth, which are not affected as magnetic previously to becoming dia-magnetic, the phenomena of revulsion are not exhibited.

I therefore submit that the metals which have been observed to change from the magnetic to the dia-magnetic states, are subject to three different conditions of molecular arrangement; first, one of magnetic polarity, and which on its cessation only induces a feeble electric current; the second, the intermediate or sluggish state, in which the metal is not polarised so as to be either attracted or repelled by the magnet, but in which there is, nevertheless, so great a molecular disturbance that very powerful electric currents are induced on its discontinuance; and the third, in which the particles are so polarised as to be repelled by the poles of the magnet which has induced such condition, but which last condition does not, on its discontinuance, induce powerful electric currents.

I have not formed a decided opinion whether the attractive revulsion exhibited by a changeable metal, when the force which has induced in it the dia-magnetic condition has ceased, is due to the action of an electric current in the contrary direction to that which occurs on the change from the sluggish state; or whether the particles of metal, in assuming their normal condition pass through the magnetic state, and are then attracted.

I leave the consideration, by what scheme or arrangement of particles such three conditions of matter and their polarities may be accounted for, as subjects for future investigation.

PROCEEDINGS
OF THE
GEOLOGICAL & POLYTECHNIC SOCIETY
Of the West-Riding of Yorkshire,

AT THE FORTY-FIRST MEETING, HELD IN THE COURT-HOUSE,
BARNSLEY, ON TUESDAY, OCTOBER 29TH, 1850.

The Right Hon. EARL FITZWILLIAM, F.R.S., President, in the Chair. The annexed statement of the accounts for the past year was submitted by the Secretary:—

STATEMENT OF THE RECEIPTS AND EXPENDITURE,
From 1st January, 1850, to 29th October, 1850.

DR.	£.	s.	d.	CR.	£.	s.	d.
To Balance in Treasurer's hands..	49	12	7½	By Printing Reports, &c.	18	3	0
To SUBSCRIPTIONS from—				„ Advertising Meetings..........	3	9	10
1 Member for 1843 at 13s.	0	13	0	„ Lithographing Plates..........	4	18	0
1 „ 1844 „	0	13	0	„ Expenses of Meetings	1	13	0
1 „ 1845 „	0	13	0	„ Collecting Subscriptions	1	2	3
1 „ 1846 „	0	13	0	„ Postage Stamps and Postages..	1	19	4
2 Members for 1847 „	1	6	0	„ Books and Stationery..........	1	7	0
4 „ 1848 „	2	12	0	„ Rent of Museum Room, &c....	20	0	0
19 „ 1849 „	12	7	0	„ Salary of Assistant Secretary ..	50	0	0
65 „ 1850 „	42	5	0	„ Sundry Small Expenses	0	18	1
1 „ 1850 at 10s. 6d...	0	10	6	„ Balance in Treasurer's hands ..	9	14	7½
Donation from J. W. Child, Esq.	2	0	0				
	£113	5	1½		£113	5	1½
Assets about	£98	17	6	Liabilities about................	£20	19	6

After a few preliminary observations, his Lordship called upon Mr. West to read the first Paper, entitled:—

COMPARATIVE VIEW OF CIRCUMSTANCES ATTENDING SOME OF THE EXPLOSIONS IN COAL MINES. BY WILLIAM WEST, ESQ., F.R.S., ASSOC. CIV. ENG.

I am not about to deliver, on this occasion, a lecture on the ventilation of coal mines; although I think that it would be highly useful to viewers and other superintendents, if, without expecting to arrive thereby at any nostrum or secret, they listened occasionally to a plain statement of the most important facts respecting fire-damp, choke-damp, atmospheric air, combustion, rarefaction, and other agents in those frightful accidents against which they have to guard. Still less have I either nostrum or secret to reveal.

But in the course of preparing two or three such lectures, not yet delivered, some circumstances presented themselves, which, however, singly, well known or obvious, have scarcely met, in connection with each other, with all the attention which they deserve. The report of Sir Henry De la Beche and Dr. Playfair,* it is true, is so able and so comprehensive, that it supersedes much which I might otherwise remark. But several minute and accurate accounts of explosions of later dates have appeared since their general report or essay was written. These enable me to draw inferences from a greater number and variety of well-recorded instances than they had then before them. Many circumstances are only incidentally mentioned, or to be gathered from casual remarks, and are therefore by no means plain on once reading. The result on my mind is a persuasion that tendencies to a dangerous condition exist in mines reputed to be comparatively safe, and that these tendencies are so numerous and vary so suddenly, that no degree of precaution of one kind can exclude the necessity of attention to others.†

The appointment of inspectors of coal mines, and the subjecting them to regular inspection, will, we may reasonably hope, diminish the frequency and the extent of these disasters. I do not anticipate that they will ever entirely cease. But this step, the appointment of inspectors, ought rather to increase than lessen the interest which scientific bodies like this should take in the discussion of past, with a view to the prevention of future, misfortunes. The same records which

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* Collieries' Report, 1847, p. 4.

† I use the term "mine," though "pit" is more common, because the latter would cause some ambiguity, since "pit" is in several of these accounts used also for "shaft." It is so in "Collieries' Report," pp. 47, 48, 49.

I have so repeatedly and minutely studied must furnish materials for study to those inspectors.

Again, it is on every account most desirable that the Inspectors should operate on proprietors rather through persuasion and representations than through the gross machinery of compulsion, fines, and prohibitions. On the Continent it is so.* In this country Government or official interference is viewed with more jealousy. We are less accustomed to it. Recommendations from authority are null unless supported by public opinion, and public opinion does not express itself, is not even formed, unless a strong interest is felt by a large portion of the community. All who consume coal, indeed, ought to have a deep, though it must be a melancholy, interest in these occurrences. Many a time when

"Shadows from the fitful firelight
Dance upon the darken'd wall;"

many a time when

"We stir the fire, and close the shutters fast,
And calmly welcome sober evening in;"

may we revert to the thought that, in obtaining the means of domestic cheerfulness for us, numbers from time to time have met with death in horrid forms, and widowhood and misery have been suddenly spread among other hearths. When such recollections obtrude, no feeling heart, no thoughtful mind, but must bid good speed to every inquiry calculated to diminish this source of human woe.

One of the first circumstances evident on comparing these accounts is, that few as they are, they embrace coal fields widely scattered, and very different in many respects. Seven explosions reported on comprehend Durham, Yorkshire,

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* In the "Darley Report," at p. 6, Mr. Tremenheere says, "In France, Belgium, and Germany, very nearly all the alterations thought right by the Inspectors, in order to the safety of the people, are obtained by frank and friendly representations alone. To use their own expressions, 'they act by persuasion and the force of conviction far more than by force of law.'" Similar statements are to be found in many other passages of his reports.

Lancashire, Warwickshire, and Monmouthshire, five districts as remote from each other as could be wished if we had made a selection. (See table.) The thickness of the beds varies from four or five to thirty feet. (See table.) The coal at Oldbury is much shattered.* At Risca† and at Coppull‡ it is very hard, so that it is considered necessary to blast it with gunpowder. At Haswell, also, though the report does not mention it, gunpowder was employed; also at Jarrow.§

Let us turn to some general remarks. Pits long and extensively worked are justly considered more dangerous than such as have been recently opened. Yet a new pit is not necessarily safe. Deep pits are generally considered more unsafe than those nearer the surface.‖ There is little reason why it should be so, unless where depth implies old or extensive working. But mere depth of shaft is favourable to ventilation where cupolas or furnaces are employed, as supplying a long column of rarefied air. The depths reported vary from 300 yards at Haswell and at Jarrow, to 130 yards and 75 yards at Darley. Some seams are much more fiery, that is, give out much more carburetted hydrogen than others. These undoubtedly are the most dangerous, and require especial care. But I find the character of the seam at Haswell to be "less fiery than many."¶ At Darley "but little fire-damp."** "No great quantity of Gas."†† So that a mine bearing a tolerable character may be the seat of repeated explosions.

That habit, and comparison with yet greater risks, can lead men to apply very gentle terms to the degree of danger in their own case, is shown in the instance of Jarrow, respecting which it is said,—"Not reputed to be very fiery, but the quantity of gas is very considerable."‡‡ In this "not very fiery" mine six explosions had taken place in twenty-eight years, causing the death of 140 persons.*

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* Report, 1847, p. 44. † *Idem*, p. 23. ‡ P. 48. § P. 22.

‖ Edinburgh Review, No. clxxx, April, 1849.

¶ Philosophical Magazine, vol. xxvi., p. 19. ** Report on Darley, p. 10.

†† Ditto, p. 1. ‡‡ Report, p. 15.

Some may be inclined to sum up and dismiss the subject with—" You must have good ventilation." But the reports, in this respect, as to some of those places where the worst explosions of late years have occurred, show the compatibility of ventilation deemed generally "good" with fatal deficiency in the hour of need. At Haswell the ventilation is reported as "most admirable."† The ventilation at Jarrow seems to have been good in the estimation both of the scientific visiters and of the workmen. Dr. Playfair says, "The testimony of those at work in the pit four hours previous to the explosion shows it to have been free from fire-damp, and well ventilated."‡ John Atkinson, a hewer, who lost a son, torn limb from limb, says, " The air was very good."§ Jacob Barnborough lost a son by the explosion, yet he says, " The air in the pit was very good; I had a son lost, but I acquit the masters of all blame in his death; there was nothing wrong in the ventilation."‖ Emanuel Dufty, " The pit was quite chokeful of air, and in beautiful working order."¶ Another, " The air was quite good, and plenty of it."** Yet, a few hours later, forty persons were deprived of life. At Risca, the ventilation was avowedly in a transition state, but no pains nor expense were spared; and a workman says, " There is famous air in the pit."†† At Coppull, Mr. W. W. Smyth, the Government Mining Geologist, says, "I found the ventilation in very good order, and have no reason to think that it had been neglected before the accident occurred."‡‡ Ventilation, therefore, such as is deemed "good" and "sufficient," does not by itself produce security.

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* Report on Darley, p. 17, Note by Dr. Playfair.

† Philosophical Magazine, vol. xxvi., p. 22. ‡ Report, P. 16. § P. 17.

‖ P. 18. ¶ P. 19. ** P. 18. †† Abiram Gething, p. 26. ‡‡ P. 49.

But a further consideration of importance presents itself. So far as the quantity of air conveyed to a certain extent of workings is concerned, (and the abundance of this, probably, would be the common idea of good ventilation), a limit, in most of these mines, seems to have already been reached. This limit arises from the inconvenience of too great velocity of current near the entrance, before the splittings take place, and in the narrower passages afterwards. At Jarrow, a witness says, " The candles swealed away." " I burnt six candles in my shift. There is more air goes through the Low Main (the seat of the explosion) than through the Bensham (the seam next above), and that has to do with it."* At Risca, " There were two or three, perhaps, working with lamps, because they could not keep their candles lighted for the draught."† James Padfield says, " You can hardly carry a candle in the wind-ways."‡ Richard Cottle says, " I was obliged to use a lamp to keep a light, the wind was so strong."§ At the Oaks, John Pickford says, " I have been obliged to take my cricket to keep the wind off my candle."‖ And Richard Hodgson, " It would sweal away a candle in two or three minutes any day."¶ Even at Darley, where the practical and scientific gentlemen agreed in considering the quantity of air to be but about a third part of what was necessary,** two witnesses state that the men complained of the wind swealing their candles,†† and their burning too many in consequence. Where this limit is thus already reached, we must look for additional security from some other source than greater strength of current. To attempt to compel the formation of new or additional shafts would be an interference of the kind which provokes resistance, since it might involve enormous additional expense. Yet it remains for the calculation of proprietors themselves whether explosions and their consequences do not exhibit a large per contra figure. Jarrow Mine, six times wholly or partially stopped, six times to be repaired and restored, in twenty-eight years, must have furnished some set off to the expense of providing different shafts for different purposes, instead of one shaft divided into three parts by wooden brattices. To place the shafts, at the first laying out of the workings, at proper distances instead of close together, would not involve, in many instances, much additional expense; and it is of great importance. At the Oaks, where the upcast and downcast were only nine feet asunder, the men and boys who reached the bottom of the shaft were kept between the danger of suffocation by after-damp, or being crushed by stones, with very few yards of fresh air. At Darley, where the arrangement of the ventilation ensured a supply of air for a considerable distance, many of those carried out as dead subsequently recovered.* At Jarrow, Jacob Barnborough, hewer, says, "If they (the masters) gave us two shafts instead of one, it would give us a better chance of escape after an accident.†" Every arrangement which tends to keep up the current of fresh air after an explosion, or to facilitate its speedy restoration, is of great importance in lessening the extent of injury to life. To nothing do the accounts more generally testify than that the greater part of the deaths take place from the choke damp, or after damp—carbonic acid gas. I find from my examination of the evidence, that at Risca it seems doubtful whether more than four or five lives were destroyed by burning, out of thirty-five lost. We have instances of stupor being produced, and recovery following after the lapse of many hours. At Jarrow, William Cranstoun recovered, after being insensible, as he believes, for thirty-six hours.* And some recovered after shorter periods in other cases. While I was writing this paper another lamentable explosion took place at Oldham (October, 1850). As the newspaper account gives many of the particulars which I have endeavoured to ascertain in the other instances, I have added it to my tables, although not included in the official reports.

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* Report, P. 18, Jacob Barnborough. † P. 36, Mr. Joseph Green.

‡ P. 38. § P. 39. ‖ P. 64. ¶ P. 65.

** Mr. Tremenheere, Darley Report, p. 1, and Mr. Smyth, p. 11.

†† Mr. Locke, the colliery agent, and George Addy, fireman. *Supplement to the Leeds Mercury*, 3rd February, 1849.

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* Report on Darley, p. 10.

† Report, 1847, p. 18.

It strikingly proves the mischief of one shaft, divided by bratticing, when an explosion does happen. The force of the blast extending to the shaft, the bratticing was in part blown out, and the entire stoppage of ventilation in the passages of the mine was but a part of the evil consequent on this. The wreck of the brattice formed a pile at the bottom of the shaft, six or seven yards high, and sufficiently solid to prevent the cage from descending for that distance. Think of men and boys, burnt, enfeebled by the effects of choke damp, and distracted by terror, climbing up a loose pile of broken wood, for six yards! Several were, in fact, maimed or hurt by falls. It was four hours before three cages could be got to the bank! One boy, clinging, in his eagerness, to the first cage after it was full, lost his hold from exhaustion, and was killed by the fall. Lamps alone were used. The immediate cause of the explosion is believed to have been a fall of roof upon a lamp which the hurriers had left upon the ground in one of the bays, while they went to the shaft bottom with a journey of coals. The seam then in working had only been opened two years, and the workings were not extensive, only 55 yards to the north, and 140 to the south from the shaft.†

I now approach what has been elsewhere a topic for many controversies—the wire gauze lamp. If it become so here, it will be, I believe, through others than me. For I am willing to yield for the time every point except one, that flame surrounded by wire gauze is less dangerous than a naked light. Whether Sir Humphry Davy was really the first inventor of the instrument named after him, whether previous attempts or later improvements are really superior to "The Davy," may, so far as my object is concerned, be left unanswered. The case is narrowed with me to "Wire Gauze *versus* Candle." Nor does it need, for a decision in favour of the Davy, that it should be safe under all conceivable, or all actually occurring circumstances. I think it a pity that the name of "Safety Lamp" was ever given to it; as "The Davy," "The Stephenson," "The Clanny," "The Upton," would not, by their mere names, have raised ill-founded expectations. There is certainly one way in which a lamp, safer than candles, but not absolutely and infallibly safe, may do mischief. This is if, in reliance upon its efficacy, work be carried on by its means in more dangerous situations, or with fewer provisions for safety, or less caution in other respects, than would have been the case were it undiscovered or discarded.* But we cannot ascribe to this any one of the particular explosions now under consideration. At Haswell, lamps alone were employed; but since the seam is stated to be

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* Report, 1847, p. 22.

† *Leeds Mercury*, October 12th, 1850.

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* "The Committee of 1835 pointed out that more persons had lost their lives by colliery explosions for the eighteen years succeeding the introduction of the Davy safety lamps in 1816, than in the eighteen years preceding the invention, and accounted for this fact by the working of numerous 'fiery' seams of coal, which had, in consequence of the assumed security of that lamp, been undertaken, and the abandonment of many precautions considered requisite when candles were commonly employed in collieries." (Report, 1847, p. 8.)

"An unfounded confidence in the lamp has been productive of great loss of life. First, by causing work to be carried on in dangerous mines, without other measures of security against explosions; and still more unfortunately, by leading to a serious limitation in the number of shafts." *(Edinburgh Review*, No. 180, p. 545.)

"less fiery than many," and its ventilation "most admirable," it is evident that it would have been worked, and worked in the same general manner, had the safety lamp been unknown. At Risca, where the general use of gunpowder would have seemed to render the precaution of lamps almost vain, only about one-third of the lights were lamps. We cannot, therefore, suppose the use of these to have caused any neglect in other respects. And at the Oaks, where candles were "chiefly" used, and at Jarrow Low Seam, Oldbury, Coppull, and Darley, where candles alone were employed by the hewers, and lamps confined to the doggy or fireman, for purposes of inspection merely, no dependence on the safety lamp can have influenced either the opening of the mines, their modes of working or of ventilation, or the conduct of the workmen. If "many precautions formerly considered requisite" have really been abandoned since the discovery of the lamp, it confirms what I am endeavouring to impress upon you, that mischief will attend every undue dependence on any one means of safety. The real question is, then, "Is wire gauze *any* protection?" "Is the lamp safer than a candle?" On these heads I have no doubt. The nature of the case, abundant observation, the testimony of scientific men, even that of pitmen, (who, however, prefer the greater light of candles,) all concur to show that, to a certain extent, wire gauze is a protection, and the lamp safer than a candle. Every time that the cylinder is filled with flame, that flame would extend, and an explosion follow, but for the wires. Sir Henry De la Beche and Dr. Playfair three times expressed their opinion that "much additional security is obtained by the proper use of the original Davy, or its improvements.*" That they "cause security in all cases where proper care is employed, though they may not be absolutely safe under all circumstances."* That "safety lamps, properly used, do effect much security in the working of coal."† Dr. Playfair again expresses his "conviction that the accident at Jarrow would, in all probability, not have occurred, had lamps been employed instead of candles" in the Low Main.‡

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* Report, 1847, p. 8.

I leave to colliers the question between higher wages, with greater danger, and lower with safety; to coal masters, whether to allow all or any part of the increased wages or allowances claimed for the use of lamps. But the testimony in favour of lamps is not confined to theorists or men of science. A workman at Jarrow, after making the usual complaint of the Davy being "so dark," is asked, "You have had long experience in pits; did you ever know an accident take place where the Davy was fairly used?" He answers, "Never."§

We have further some very interesting facts, furnished not by a philosopher writing in his study, but by a viewer at Walker Colliery, near Newcastle-on-Tyne. On November 13th, 1846, when approaching a slip dyke, a mass of coal was displaced, weighing about eleven tons. On the displacement of this block, and the discharge of fire-damp that followed, being observed by the two men working in the drift, they immediately extinguished one lamp, (the other having been put out by the accident,) informed the other men in the pit, and retired to the shaft. The air rendered foul in an instant was ascertained by subsequent measurement of the passages to which it extended to be more than 40,000 cubic feet. A second violent discharge took place from near the same spot on the 10th December. Judicious precautions had been taken to prevent mischief. While the men were breaking down a portion of roof, to enable the tram-road to be carried up, the "danty" or broken coal in the slip of the dyke, above where a bore-hole had just been made, was violently forced out, with a noise, continuing for some time, which resembled the blowing off of an immense high-pressure steam-engine, and a violent discharge of gas, that extended over a distance of 640 yards in length, with an area of 86,000 feet. At 400 yards from the point of issue it was met by one of the deputies. Though he drew down the wick of his lamp, the gas continued to burn for ten minutes, heating the wire red hot, and leaving the particles of coal attached to the wire gauze burnt quite red. At the end of the 640 yards, the gas burnt within the lamps of five men and boys there employed, until they extinguished them in a sump or pool at hand. There can be no doubt, therefore, that the explosive mixture extended still further. Where would the workmen on these occasions have been but for the lamp?

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* Report, 1847, p. 9. † P. 11. ‡ P. 17. § P. 19, Emanuel Dufty.

A low state of the barometer is obviously favourable to the discharge of gas. Many practical men are aware of this. The most curious instance of its operation is that mentioned as occurring in a pit of Mr. Jobling's, of Jarrow, where, with a low barometer, inflammable gas was habitually noticed to issue from the coal; while, when the barometer was high, common air was observed to enter the coal at the very same fissures. But how many of those whose employment it is to inform the workmen when caution is requisite possess or understand a barometer?

I was the more encouraged to bring forward this paper by finding, as I proceeded, that several circumstances then acquired an interest, in connection with others occurring elsewhere, which they by no means possessed while detached. But a cursory perusal of the accounts, by persons ever so well acquainted with the subject, would not exhibit these in their full force and bearing.

I have attached to this paper some tables,* which include most of the particulars admitting of comparison. On some desirable heads the accounts give little information, such as the quantity of air computed to enter, the kind of roof and of floor, &c. And I should wish to see inserted in future accounts several heads respecting which our present accounts furnish no materials. Such are—the speed of the air current in the principal air passages; the amount, and kind, and period of sinking in the country above, &c.

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* The Diagrams on the wall contained these Tables, a little abbreviated.

It is remarkable that at three of those places from which we have the most particular accounts, coal getting had been suspended shortly before the accidents. At Jarrow, for six days, until four days before the explosion. At Risca the day before,* and at Darley the day before,† respectively. The events might create a doubt whether the ventilation had in each case been carried on as actively during the intervals as if the usual labours of the pit had been continued. This subject was not remarked on by the Government Commissioners, or, so far as appears, by the Coroner, in either case. Whether, in these instances, it be a significant fact, or only an accidental coincidence, it is quite clear that ventilation should never slacken. The gas is constantly issuing in pits subject to it, and it will accumulate during the absence of the men, to be ready for any contingency favourable to its inflammation after their return, unless it be in the mean time, and as fast as it issues, diluted and carried off. It is also observable that at Risca both the firemen had, through illness, or being engaged elsewhere, entrusted, on that day, their usual duties to others. At Darley also there had been a change, though both must be supposed equally skilled. George Addy, fireman, who had gone down to "try the fire" daily for two years, being ill, Joseph Thompson, the bottom steward, took his place. I attach no importance, however, to this. Let me remark that, in commenting on the circumstances attendant on any of these sad catastrophes, I mean no unkind or unhandsome reflection on any of the parties concerned. Those circumstances are as much matter of history as the explosions themselves, and as such are open to fair and candid remark. The "scaling off" of a portion of fresh air to feed the furnace, recommended by Mr. Warington Smyth,[*] and conducting the return air into the upcast shaft at a safe height above the fire, occurs as being practised in none of these reports. For want of this the fire in the furnace at Risca, and that at Darley, had to be put out just when a powerful current of fresh air was most wanted. And time, any moment of which might make the difference of life or death to some perishing sufferer, was spent in giving the needful directions, or waiting for their fulfilment. Double doors, allowing a corve or tub to enter the space between, and the first to be shut before the second is opened, prevent even the momentary interruption of the proper ventilation, and lessen the danger of a disarrangement of longer continuance from accident to, or neglect of, a single door. They are referred to by Sir H. De la Beche, but in the other cases the doors seem to be single. I believe they are very commonly so.

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* Collieries' Report, p. 36.

† Darley Report, p. 10, and *Leeds Mercury*.

Oldbury appears to be the only mine where the upcast shaft was unprovided with a furnace. The catastrophe at this place produced a pamphlet, or rather a book, from a gentleman of that neighbourhood, which consisted almost entirely of the advice to build a tower over the mouth of the upcast shaft, thus increasing its length, and not to use furnace or fan, or any other artificial means of producing a current. I do not agree with him. Mr. Smyth recommends a tower or stack at Darley, where the up shaft is much shorter than the down, but would retain the furnace.

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[*] Darley Report, p. 16.

I am not prepared to say that the employment of gunpowder should be forbidden, or that a seam which cannot be profitably worked without it should be abandoned. But I do think that the difference in cost between gunpowder and the pick alone should be considerable, to render blasting, on the whole, advantageous to the proprietor. That it forms of itself a naked light, and thus renders almost nugatory the use of lamps, is obvious. The sudden dislodgement of large masses of coal must favour sudden and rapid discharges of gas; while the loose, open, shattered condition, which it is the very object of blasting to produce, is no less favourable to keeping up the emission. When the coal is cracked and crushed, the pillars or "posts" left must either be larger, or they will be weaker, and not the coal alone, but the roof, will suffer, and those "falls" of stone or shale take place which are the causes of fatal accidents in various ways, and explosions among the number. It is not, then, alone a question between so many pounds of gunpowder on one hand and so many weeks' additional wages on the other; the coal shaken by blasting is also less valuable, from the readiness with which it falls into "slack."

Many considerations point to the goaf or wastes, or worked out portions of a mine, as the source and seat of explosions. The evidence, it is true, must be, from the nature and results of the calamity, inferential, rather than direct. What no living eye has witnessed, no living tongue can remain to tell. But in the Haswell Colliery, and in some other cases, satisfactory evidence as to where the gaseous mixture fired was afforded by the direction in which its force acted, and by the condition and situation in which the bodies of some of the pitmen were found; and the goaf of thirteen acres was there indicated as the largest reservoir of gas. At Jarrow the waste was clearly pointed out. At Risca the evidence shows that the immediate cause of the accident was a man (William Curtis) going into the gob, where he ought not, with a candle.* At the Oaks, the upper class of witnesses, skilful in coal working, after hearing the evidence as to the finding of the body of William Walton, came to a like conclusion as to the cause of explosion there.† (See table.) But even before this they imputed it to a fall of roof in the south waste.‡ In either case the waste is concerned. From Oldbury and from Coppull I have not the reports of the evidence at the inquests; my information and my tables are therefore less full and precise as to those two than the others. At Oldbury, however, the "old sides" were professedly walled off, but two of the walls were "uncapped;" "probably not produced by the accident," says Mr. Warington Smyth.§ The old sides, or waste, therefore, most likely, were concerned. At Coppull, "the roof is free from gas, and even after it has fallen down, and left large cavities above, is said not to harbour any other noxious gas than 'black damp.'"‖ But if not given out by these cavities, it must collect in them. At Darley Mr. Tremenheere says, "The colliery was worked on a plan by which, as the coal was got out, large cavities were left, only partially filled up by the breaking down of the roof; and those cavities became so many magazines of explosive gas." In at least four mines, then, the great reservoir of inflammable gas was the goaf, and in three others very probably so. At Oldham alone was the gas collected evidently in the working parts, or bays, of the mine.

We need not wonder, then, seeing the special danger which attends the goaf, that Faraday and Lyall, at Haswell, directed their attention almost exclusively to some special means of ventilating it; nor that in the instructions issued by the Secretary of State for the Home Department, this subject occupies a distinct head. But the more carefully and repeatedly I peruse these reports, or converse with practical men on this part of the subject, the more I find discrepancies, amounting almost to confusion, as to what is now attempted, what is now accomplished, or what can at any time hereafter be hoped for. And the difference in the accounts on this head does not appear to depend on real differences between the mines themselves, so much as on variety of belief, or of modes of expressing belief, as to what now takes place. On the whole, the following expressions seem to convey the general opinion—"Sweeping the outskirts of one or two gobs."* "Coursing by the side" of the goaf.† "Passing round it."‡ "This current takes its way sluggishly through the lower parts of the goaf, or moves round the outside of it."§ "All that oozes from it into the workings is removed by the air courses."‖ But if there be any truth in the description given by Faraday and Lyall, of the space above a goaf as an inverted basin of inflammable mixture, whatever difficulties may attend their plan, or any other, for its separate ventilation, only on effecting this depends our deliverance from the greatest danger of all. Many passages in these reports, too long to quote, confirm the accuracy of their description, and I might say of my own. Their statements are not matter of opinion, but of the most undeniable calculation, as to many thousand cubic feet of explosive mixture issuing at one spot, upon a sinking of the barometer, of only one-tenth of an inch, or a fall of roof, lowering the upper edge of the goaf basin only three inches. They understate their case, for they suppose only one-tenth. The fall within a short time is often greater; and they take for a basis the Haswell goaf of thirteen acres, instead of the Felling, or the Jarrow Bensham seam, of 100 acres each. More than all, they assume the goaf mixture to be itself simply explosive, instead of being capable of rendering explosive many times its own bulk of previously pure air. This latter must more often be the case.

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* Report, p. 38.

† Joseph Littlewood, p. 63; B. Byram, Esq., p. 66; Mr. Utley, p. 66.

‡ B. Byram, Esq., p. 66.

§ Report, p. 47.

‖ P. 47.

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* Coppull, p. 48. † Oaks, p. 57. ‡ Oaks, p. 57.

§ Farady and Lyall, Phil. Mag., p. 23. ‖ P. 57.

Keeping in view these facts, to "sweep the sides" of a goaf, or carry off what "oozes" from it, may carry an explosive mixture to naked lights at a distance from the goaf, but cannot prevent its formation, or its discharge. And to pick up every stone from the floor, as held out at Jarrow, incomprehensible as it seems—or to pierce the fault bounding the south waste at the Oaks—would leave the goaf cavities untouched. It is not clear at what levels the "permanent windways over the gobs" at Risca[*] are placed. If they are at the top of the highest cavity in that weak shale, the first part of Faraday and Lyall's recommendation is effected; it is, therefore, practicable. What is further wanting is to carry off the goaf air separately, instead of into the air courses of the workings. If they are only at the level of the roof before its breaking down, they also leave the hollows untouched. Sir H. De la Beche and Mr. Smyth say, "The height to which it (the gas) might be mixed with the broken roof could not be estimated."[†]

As to sinking of the surface, I have heard persons engaged in coal mining converse on this matter as if, very soon after the last procurable coal was extracted, and the "juds" drawn, the roof settled down quietly, evenly, and entirely from the top, to meet the floor, or creeps in it, until the whole cavity is filled at the expense of the surface. Now I know that the instances of subsidence are very curious, but their being objects of curiosity implies some degree of rarity. I believe the complete filling up of old mines from this sinking process to be slow, irregular, and by no means to be depended on. This is implied also in several passages of these reports.

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[*] Report, p. 57.

[†] And Faraday and Lyall (p. 20)—"How high the heap of broken strata, and the vaults inclosing it, extend, is not known in a large goaf, nor, as far as we are aware, even in a small one."

We have the river Sirhowey flowing over the works of Risca colliery. Indeed, among the many mines of all kinds carried under rivers or the sea, I remember but two or three instances of flooding by irruption of water from the surface.

I have omitted many interesting particulars, out of regard to your time, and to the authors of other papers. The printed documents will well repay the attention of persons of all ranks engaged in such undertakings. It would be a great mistake to suppose that the appointment of inspectors in the least degree relieves proprietors or managers of collieries from responsibility, or that it will at all cramp their own exertions for the preservation of their property, and of the lives of their workmen. The intention is, and if all classes concerned do their duty, the effect will be, to assist, as well as to stimulate, individual exertion. It is much to be hoped that from the time when the inspectors about to be appointed commence their operations, they will collect, record, and publish all such particulars of every explosion of mark as may furnish to themselves, other inspectors, proprietors, and agents of every description and name, the means of learning from them what to adopt and what to avoid, for the purpose of preventing, or rendering less destructive, these calamities.

I do not deem it needful to dwell long upon that undeniable and prominent source of danger—the carelessness or fool-hardiness of workmen. We find from the evidence in several of the cases that they have strong objection to lamps, on account of their giving less light than candles.[*] Mr. Green, at Risca, says, "I have much trouble with the men respecting the use of the lamp. I have frequently been obliged to make them an allowance, either by putting a boy with them, or by giving them an extra price, when they were asked to use the lamp. *I have many times seen colliers with the safety lamp hung up by them burning, and they working with a naked candle, also burning, close to each other.*"[†] Nowhere did the workmen complain that they could not readily obtain lamps, but wherever the subject is mentioned, we find unwillingness to use them; and this, although, as the evidence implies, the cost of lamps, oil, and wick was borne by the masters, but that of candles by the men themselves.[‡]

Mr. Smyth says, "Men have been known to dash to pieces Upton and Roberts's lamp, on account of its weight.[§] As candles could always be smuggled into the pits, there appears little prospect of effecting, by compulsion, the general use of any safety lamp. Unhappily, the case of a coal mine, so far as explosions are concerned, differs from that of a ship, and from many other dangerous occupations, in that the care of the most prudent does not secure even themselves, while the carelessness of one may at any time involve the whole in destruction. At Jarrow, and at the Oaks, the immediate cause of explosion seems to have been, in each instance, a man going with a candle into a part of the waste notoriously unsafe; at the Oaks, too, after being repeatedly warned against it. The story is familiar to many, of Dr. Faraday, during his inspection of the Haswell mine, after the accident there, asking of the group of smokers among whom he was resting, "Where is your powder?" and being startled from his rest by the answer, "You are sitting upon it."

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[*] John Bainbridge, p. 20, at Jarrow.

[†] Report, 1847.

[‡] P. 54.

[§] P. 47.

The remedies for insensibility to their own preservation, and that of their fellows, must be chiefly of a moral nature, and must be very slow in their operation, requiring generations to produce much effect. Mr. Tremenheere shows, in a passage too long to quote, how, without compulsion, a taste for some degree of mental cultivation may be induced, and some degree of intellectual advance imparted. We must make great allowance for the very low state of degradation, and the almost complete isolation from the rest of the community, in which, a century ago, colliers were sunk. In Scotland they were, by law, a kind of serfs. On the Tyne, at Kingswood, and in Staffordshire, they were wholly a distinct class—the amusement, the wonder, and the terror of their neighbourhoods. I have lived near coal mines for forty years; I believe it is neither fancy, nor use alone, but some degree of approach towards the habits and manners of other workmen, which renders it far less easy to me to distinguish at a glance a collier, whether man or boy, by his dress, gait, and features. However this may be, they are human beings; and those masters and managers who, not only by liberal wages, but by kindness, and the evidence of their own concern for the men's safety, attach these to them, will have a security for the observance of needful regulations, stronger and more constant than fines, or sudden and angry dismissal.

I concur with most of the conclusions to which the different scientific reporters have come. I need not recapitulate them at any length. More shafts; separate and, so far as may be, distant shafts; scaling fresh air to the furnace; effectual ventilation of goafs, if possible; increased use of lamps; increased care and intelligence among the workmen, especially the firemen, wastemen, &c. The evils

TABULAR VIEW OF SOME RECORDED EXPLOSIONS.

Seam or Pit, Place, and County.	Date.	Reported on by	No. in Pit.	No. Killed.	Character as to Gas.	Condition on that Day.	Character of Ventilation.	Air. cubic feet ℔ min.	Speed of Air current.	Longest Distance traversed by the Air.	Kind of Lights used.	Apparent or supposed Cause of Explosion.	Improvements recommended or suggested in the Reports.	Statements as to Waste of Candles.	Former Explosions in same Pit.
Little Pit, Haswell, Durham.	Sept. 1844	Dr. Faraday and Sir C. Lyall.	...	95	"Less fiery than many." "As little as any in that part of England."	Good.	"Most admirable."	25,400	...	...	Lamps only.	Fall of roof on a lamp in drawing Jud.	Drawing off the gas from the goaf, separate from the general ventilation.	"Almost impossible to keep a candle lighted in the windways."	...
Lower Seam, Jarrow, Durham.	Aug. 1845	Dr. Playfair.	37* 41†	36* 5†	Not reputed very fiery, but quantity of gas very considerable.	"No blower or other unusual escape observed."	"Sufficient." (Dr. P.) "Very good." (Pitmen.)	40,000	9 ft. per second in shaft	...	Candles in the Low Main	......	Additional shafts. Use of lamps in the "Low Seam."	Great complaints of "swealing."	6 in 28 years.
Black Vein, Risca, Monmouth.	Jan 1846	Sir H. De la Beche and Mr. W. W. Smyth.	150	35	"As a whole, much gas." "Very fiery." (Pitman.)	"Examined that morning; no gas observed."	Sufficient air; the plan in a "transition state."	Never observed.	...	1½ mile	⅓ lamps. ⅔ candles.	Man going into goaf with a candle.	An additional shaft and other arrangements for ventilation, as then in progress.	Some "worked with lamps because they could not keep a candle lighted," &c.	...
Rounds Green Oldbury, Warwick.	Jan. 1847	Mr. W. W. Smyth.	...	25	......	......	"No efficient system of ventilation can be said to exist."	...	...	...	Candles, except doggy.	......	A furnace, or else a tower or chimney. Air-ways larger, carried to the top of the coal, and kept in advance More care as to stoppings.	......	...
Burgh, Coppull, Lancaster.	Jan. 1847	Ditto.	...	9	"Quantity of gas rather large."	......	......	...	...	Nearly 4 miles	Candles, except fireman.	......	Better upcast draught. Shorter total air-course. More care as to stoppings and doors. Brattices to be carried nearer to the faces of work. Obedience of men to rules.	......	..
Ardsley Main or the Oaks, Barnsley, Yorksh.	Mar. 1847	Sir H. De la Beche and Mr. W. W. Smyth.	...	73	"Average quantity."	Not complained of.	......	...	...	...	Chiefly candles.	Man going into goaf with a candle.	Shafts too near each other. (A third shaft intended.) Lamps alone to be used near the goaf. (Works ill laid out by former proprietors.)	"Would sweal away a candle in two or three minutes, any day," &c.	...
Darley Main, Barnsley, Yorksh.	Jan. 1849	Mr. Smyth, Mr. Tremenheere, and Newspaper.	101	75	"But little."	"No sulphur." "As usual."	Quantity of air too small.	Average 9,000	...	...	Candles.	High wind, interfering with ventilation.	Much more air. (Mode of working disapproved.) Air should be "scaled off" for furnace. Upcast shaft too shallow; a tower or stack wanted.	"The men grumbled hard at the air swealing the candles," &c.	3 in 2 years.
Oldham, Lancaster.	Oct. 1850	Newspaper.	35	15	Not stated; must have been large, since lamps only were used.	......	......	...	..	...	Lamps only.	Fall of roof on a lamp in the workings.	Obviously one or more additional shafts.	......	...

* In Low Main. † In Bensham.

TABLE 2, CONTAINING CHIEFLY ENGINEERING PARTICULARS.

Place.	Shafts.		Depth.	Extent of Work.	Thickness of Seam.	Dip.		Throws.	Character and Hardness of Coal.	Roof.	Floor.	Statements as to Goaf.	Kind of Explosion.	Mode of Working.
	No and Distance.	Diameter.	Yards.	Acres.	Feet.									
Haswell.	......	......	310	250	5¼	1 in 24	To S. E.	Almost free.	Seam very regular. Some gunpowder used.	Shale and sandstone; very secure.	Sandy clay; not apt to rise in creeps.	One of 13 acres.	Believed to have been two.	......
Jarrow	1 bratticed into 3.	14 feet.	390	...	5	1 in 32	To S.	Several slight.	Some gunpowder used.	......	......	Said to be kept clear.	Two; the last worst.	......
Risca.	2—24 feet.	Down 9; Up 16 by 10.	146	...	6 to 18 Aver. 9	Curved; 1 in 2 to 1 in 6	To N. W.	Some.	Very hard. Gunpowder said to be necessary.	Carbonaceous shale; not strong.	Soft.	Wind-ways over them.	Small in proportion to damage done.	......
Oldbury.	2—a few yards; No furnace.	7 feet.	180	Small at one time.	30	Irregular.	To S. W.	Very many.	Much shattered and injured. The height forbids the use of lamps.	Tender bind; in some parts sandstone.	......	Walled off.	......	In "sides of work."
Coppull.	2 near; 1 at considerable distance.	Down 12; Up 7.	154 140	200	5	7	...	Very many.	Gunpowder said to be necessary.	Carbonaceous shale; tolerably secure.	......	"The air sweeps the outskirts."	......	......
The Oaks.	2—9 feet.	Down 9 to 10¾; Up 9.	283	...	8	11 and 14	To E.	1 Up, 17 ft. to W.	......	Shale; readily breaking away.	......	"Air-courses by the side." "Air passes round it."	......	Long, or Shropshire.
Darley	3	2 Down, 9¼; 1 Up, 9½.	131 75	120	8	......	...	One principal.	......	......	......	......	Small and slow.	Intermediate; between post and stall and long wall.
Oldham.	1 bratticed into 2.	......	221	Small.	4¾	......	To S.	......	......	......	......	......	......	......

attendant on blasting; the use of firemen understanding and observing the barometer; the error of supposing the wastes to fill up rapidly and entirely by subsidence; and, most of all, the hopelessness of increasing the speed of the air current, where candles are used, much beyond its present rate;—these are among the considerations which either have not occurred to those reporters, or have impressed me more strongly than they appear to have done these writers.

I end as I began; all that I have here collected and compared, all besides that I have read, all that I hear, even from those who advocate reliance on some single means of defence, convinces me that a single means is not enough. It will not do to trust alone to a strong current of air, to the superiority of "long" methods of working over "short," or "short" over "long," to the use of lamps, to frequent and minute inspection, or to regulations for workmen. Let each, or any, be observed; but let no other helps to safety, which are applicable to the situation and circumstances be neglected.

ON THE EXISTENCE OF FOUR CRYSTALLINE SPECIES OF CARBON. BY H. C. SORBY, ESQ., F.G.S.

The four species of carbon are diamond, graphite, hard coke, and charcoal. They have long been distinguished practically; and the object of the present paper is to show their various crystalline forms and mutual relationship.

In the first place we have diamond, which is well known to be crystallized in the regular system, and to have a specific gravity of about 3.52.

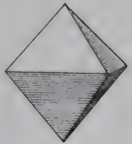
Secondly, we have graphite or plumbago, which is found crystallized in regular hexagonal prisms, and has a specific gravity of about 2.18.

But besides these I find that there are two other crystalline species, viz., hard coke, which, like diamond, belongs to the regular system, though it has very different properties and specific gravity, viz., about 1.89; and anthracite or charcoal, crystallized in the square prismatic system, and having a specific gravity of 1.77. These various forms are shown in *Figs.* 1, 2, 3, and 4, *Plate II.*

The manner in which I have been able to ascertain the crystalline form of coke, anthracite, and charcoal, is thus:—I bruise a portion in a mortar, along with soft chalk, which protects the fragments from injury, and then dissolve away the chalk with acid, and wash the powder left; then spreading some of it on a piece of the thin glass used for microscope object covers, and drying it, I examine it through the glass with a magnifying power of about 400 linear, and measure the angles by means of the doubly-refracting goniometer, invented by Dr. Leeson. By this means, and using proper precautions, the angles of a fragment of $\frac{1}{4000}$th of an inch in diameter, or even less, can be measured within a small fraction of a degree. Of course by this method one can only ascertain the magnitude of the angles which occur on one plane; but by measuring those of various fragments, one can, by calculation, build up from them the primary form from which they are derived.

It is not every sample of coke which shows the crystalline structure well. Those which are highly vesicular do not show it at all distinctly; but if we take a dense, highly-metallic-looking specimen, although the particles which have good angles well placed for measurement are rare, yet still sufficient can be found by a patient examination to show that it belongs to the regular system. The angles which are good and distinct are, I may say, invariably found to be of 90°, 60°, 30°, 45°, and 70½°, all of which are related, in a very simple manner, to the regular system; and I would

1



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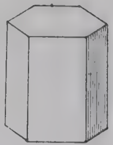

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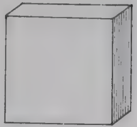

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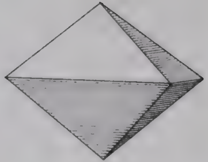

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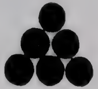

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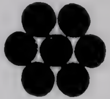

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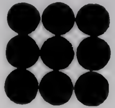

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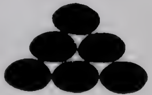


remark, that the angles found by careful measurement agree with those calculated, as near as could be expected from the nature of the case. The angles found in anthracite are $80\frac{1}{2}^\circ$, $99\frac{1}{2}^\circ$, 90°, $40\frac{1}{4}^\circ$, $49\frac{3}{4}^\circ$, 62°, 118°, 31°, 59°, 45°, $22\frac{1}{2}^\circ$, $67\frac{1}{2}^\circ$, $16\frac{1}{2}^\circ$, $74\frac{1}{4}^\circ$, $52\frac{3}{4}^\circ$, and some others; the manner of derivation of which, and their mutual relationship, would require too much explanation. They are all, however, easily shown to be readily derivable from a square prism, which has its axes related as 5, 5, and 3, and which is not only cleavable with relation to those values of the axes, but also to the axes 5 and 5, and four times the axis 3; and that it is thus cleavable many fragments prove very clearly. I would also remark, that careful measurements agree, within a few minutes, with the angles calculated on these suppositions. Although charcoal is unfavourable for such an examination, yet I have found in it angles which agree with those of anthracite, as near as could be told.

Carbon is, therefore, crystallized in three different forms, viz., the regular and square prismatic systems, and in hexagonal prisms: and what is remarkable, (in fact, it is the only case of the kind known), it occurs in two perfectly distinct conditions, with different volumes, viz., diamond and coke, in one system of crystallization, the regular; making, therefore, four distinct species.

I will now explain what I believe to be the mutual relationships of these four species, and afterwards show in what manner their properties differ.

In order to determine the specific gravity of graphite, coke, anthracite, charcoal, and lamp-black, with sufficient accuracy, it is necessary to have them in a state of very fine powder; and in the case of charcoal it is absolutely essential to boil it first in acid, to dissolve away the glaze of ashes. I first heat the powder to dull redness, without access of air, and then thoroughly well boil it in water in a bulb of glass, and fill it full of boiled water, and cork it. By this means the water, being deprived of air, when cold, dissolves any that may be amongst the powder. It is then weighed in water, and after that dried in the bulb, from which the weight in air is told. It is then burned to ashes, and their amount, and also their weight in water, ascertained; and these, being deducted from the weight of the substance in air and water, we are able to calculate its specific gravity, free from the effects of the ashes. In this manner I find the specific gravity of the different varieties of carbon to be thus, which are mean results of several experiments, the details of which it is needless to particularize here:—Graphite 2.177, hard coke 1.891, lamp-black 1.774, anthracite 1.760, and charcoal 1.784. I have not examined the specific gravity of diamond, but the mean of many statements is 3.521.

Now I have ascertained the following remarkable fact with regard to these specific gravities. If we assume the ultimate atoms to be spheres in the regular system and the hexagonal prism, and spheroids in the square prismatic, and calculate mathematically the relative specific gravities that we ought to have, assuming them to be arranged in the manner indicated by the crystalline form and cleavage, we find that the whole of the four species of carbon are brought about by its existing in ultimate atoms, having the relative volumes of $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$.

In the first place, beginning with the square prismatic system, the mean specific gravity is 1.773, and this, multiplied by 2, gives 3.546 for the specific gravity of diamond; assuming the atoms to have their axes of the same relative magnitude as those of the two crystalline forms, and arranged similarly, that is to say, in the case of diamond, spheres, and in the other spheroids, with axes in the ratio of 3 and 5, as shown in *Figs*. 1, 5, 4, and 8. The mean of many statements of the specific gravity of diamond, which vary from 3.48 to 3.6, is 3.521, which differs from the calculated specific gravity by only $\frac{1}{140}$th. The volume of these two forms is, therefore, as $\frac{1}{2}$ to $\frac{1}{4}$.

Suppose the spherical atoms of diamond to be arranged as an octahedron, *Fig.* 1, in that case they would be placed with relation to one another on each equilateral triangular face, in the manner shown in *Fig.* 5; and such an arrangement agrees perfectly with the well known cleavage of this mineral. Also let us suppose the atoms of coke to be spheres, but arranged as a cube, *Fig.* 3, in which case they would be related to one another on each of its square faces, as shown in *Fig.* 7. On these suppositions it is easily shown mathematically that the relative volumes would be as $1 : \sqrt{2}$; and calculating on this supposition, and also that the volumes of the ultimate spheres in coke are to those in diamond as $\frac{1}{3} : \frac{1}{4}$, we should have for the specific gravity of coke, by calculation, 1.880. Four very careful experiments, which only differed by $\frac{1}{600}$th from one another, gave me a mean specific gravity of 1.891, which only differs from that calculated by $\frac{1}{180}$th.

Again, supposing the spheres of coke and graphite to be of the same magnitude, but in the latter arranged as an hexagonal prism, *Fig.* 2, in that case they would be related to one another on the terminal planes, in the manner shown by *Fig.* 6, and rectangularly in the direction perpendicularly to them, a structure indicated by the crystalline form and cleavage. If such be supposed, it is easily shown that their relative specific gravities should be to one another as $\sqrt{3} : 2$; and this gives for the specific gravity of graphite, by calculation, 2.172. The mean of six careful experiments gave me 2.177, which only differs from that calculated by $\frac{1}{400}$th.

I think, therefore, that these calculated results agree so very well with those found by experiment, that I am entitled to conclude, as I before said, that the four species of carbon are caused by its existing in atoms of the relative volumes of $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$, arranged in such a manner as the form and structure of the different crystals indicate; and what makes this fact very interesting is, that there is no case known at all similar, with respect to any other elementary body.

There is one fact of very great theoretical importance connected with these relative volumes, viz., their specific heat. In the case of charcoal and diamond I had predicted a considerable time before I knew that it was so, that their relative specific heats would be as 2 : 1; and such is really the case. Moreover, the specific heat of coke and graphite is the same, whereas it is to that of diamond as $\frac{1}{3} : \frac{1}{4}$, and to that of charcoal as $\frac{1}{3} : \frac{1}{2}$; whence it will be seen that the specific heat of the four species of carbon is in precisely the same ratio as the volume of their atoms; or in other words, the capacity for heat of the atoms of carbon, when of different volumes, varies in the same ratio with their magnitudes, which I believe to be an entirely new law as regards an elementary body. To render these facts more apparent I subjoin the following table, which is calculated from the found mean specific gravity and heat of the square prismatic form:

	Square Prismatic form	Coke.	Graphite.	Diamond.
Specific gravity—				
Theory	$2 \times \sqrt{2}$ 1.773	3×1 1.880	$3 \times \sqrt{\frac{2}{3}}$ 2.172	$4 \times \sqrt{2}$ 3.546
Experiment......	1.773	1.891	2.177	3.521
Comparison of theory and experiment ...	...	$\frac{1}{180}$ too little	$\frac{1}{400}$ too little	$\frac{1}{140}$ too much
Relative volume of atoms	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{4}$
Specific heat—				
Theory	$\frac{1}{2}$ .2714	$\frac{1}{3}$ .1809	$\frac{1}{3}$ .1809	$\frac{1}{4}$ .1357
Experiment......	.2714	.2028	.2019	.1331
Comparison of theory and experiment ...	...	$\frac{1}{9}$ too little	$\frac{1}{9}$ too little	$\frac{1}{50}$ too much

NOTE.—In this table, in the upper line of figures, the number on the left hand side of the × indicates the inverse volume of the atoms; and that on the right the correction required for difference in crystalline form and arrangement of the atoms.

These specific heats are not from my experiments, but are the mean of those given in Gmelin's Hand-book of Chemistry; and though they differ considerably from theory, yet to any one acquainted with the nature of the experiments, and the usual great difference, as determined by various authors, it will not appear anything more than what might result from errors of observation.

If we take into consideration only the specific gravities, this law is not at all apparent; for, as I have shown, the specific gravity is not a simple function of the volume of the atoms, but a compound one of it and of the crystalline form and arrangement of the particles; whereas the specific heat is a simple function of the volume, and is in no way related to the crystalline form. So far as I am aware, this important distinction has been overlooked in discussing the relative specific gravities of various bodies.

Gmelin, in his Hand-book of Chemistry, in mentioning the relation of the specific heats of the various forms of carbon, says—"The capacity for heat of carbon in the form of diamond is one-fourth, in that of graphite one-third, and in that of charcoal one-half the ordinary amount. These exceptions cannot be explained away; we cannot triple, quadruple, nor even double the atomic weight of carbon without incurring great inconvenience." I, however, think that, from what I have shown to be the case in carbon, chemists will not insist on a constant, perfectly simple ratio between the specific heat and atomic weight of elementary bodies, since they may exist in different relative volumes, and thus much modify the relation of their specific heats.

The properties of these four species of carbon, as is well known, vary very remarkably, and it may, perhaps, be well to mention some of the leading differences between them.

In the first place, the distinction between diamond and charcoal is very great, and has long been a subject which has excited much attention and surprise; and has hitherto, in my opinion, been referred to a very wrong cause, viz., mere molecular arrangement. Diamond is twice as dense, it is colourless and transparent; whereas the other is black and opaque. Its hardness is incomparably greater, and it is a non-conductor of electricity; whilst the other conducts tolerably well. It becomes positively electric by friction; whereas anthracite becomes negatively so.

The chief difference between diamond and coke is, that diamond is colourless and transparent, but coke is opaque and has a metallic lustre. It is a non-conductor of electricity, but coke conducts extremely well. It is also much harder than coke; for though coke cuts glass, and even scratches topaz, it will not scratch corundum. Diamond, as is well known, is converted by intense heat into the coke form of carbon.

Coke and graphite have both the same metallic lustre, and differ chiefly in hardness; graphite, when pure, being vastly softer. When coke is used for the electric light, that piece which is attached to the anode is softened, and partly converted into graphite, and its specific gravity is thereby increased; whereas that attached to the cathode is unaltered.

With regard to the square prismatic form of carbon, I would state that anthracite, charcoal, and lamp-black belong to it; and the chief difference between them and coke is, the want of the metallic lustre which the latter possesses. It is also very much harder; for anthracite will not scratch calcareous spar, whereas coke is inferior in hardness only to diamond and corundum. Coke is also a very much better conductor of electricity than they are. When exposed to a white heat, anthracite will cut glass like coke; and both it, charcoal, and lamp-black, when thus heated, conduct electricity vastly better than when only heated to dull redness. The specific heat of charcoal is also diminished. I therefore think that the ultimate atoms are converted into the coke form, though they retain their former crystalline structure, and are therefore pseudomorphous. It is, however, remarkable that the specific gravity of anthracite is not increased by this treatment, when it is determined from fine powder.

One point of geological interest in this inquiry is, the fact that anthracite is found in the same condition as wood takes when exposed to a red heat, and not that produced by the action of heat on coal; for in the latter case we, I believe, invariably obtain the coke form. Why this should be so I will not venture to say, farther than that perhaps it may be owing to the manner of heating, joined to the great pressure which must usually have been in operation in the case of coal converted into anthracite. Moreover, it should appear that anthracite cannot have been exposed to a white heat, or else it would, in all probability, have been converted into pseudomorphous coke.

As to the manner in which anthracite has been converted into graphite, the fact of the piece of coke which is attached to the anode being converted into it, and not that to the cathode, would point not so much to the mere effect of heat, as to the combined action of a positively electric condition.

I should therefore conclude, from various circumstances, that diamond has been formed at a low temperature; the square prismatic or charcoal form at about a red heat; the coke form at a still higher temperature; and graphite at an intense heat, combined with the action of highly-developed positive electricity; and it is worthy of remark that the relation of their specific gravities, as calculated and as found by experiment, coincides with this view of the subject. I have compared them by calculation, (see table), supposing the charcoal form to be normal, and it will be observed that the specific gravity of diamond is lower, and those of coke and graphite higher, than indicated by theory; which agrees perfectly with the supposition of its having been formed at a lower, and they at a higher, temperature.

ON A NEW GAS STOVE. BY W. SYKES WARD, ESQ., LEEDS.

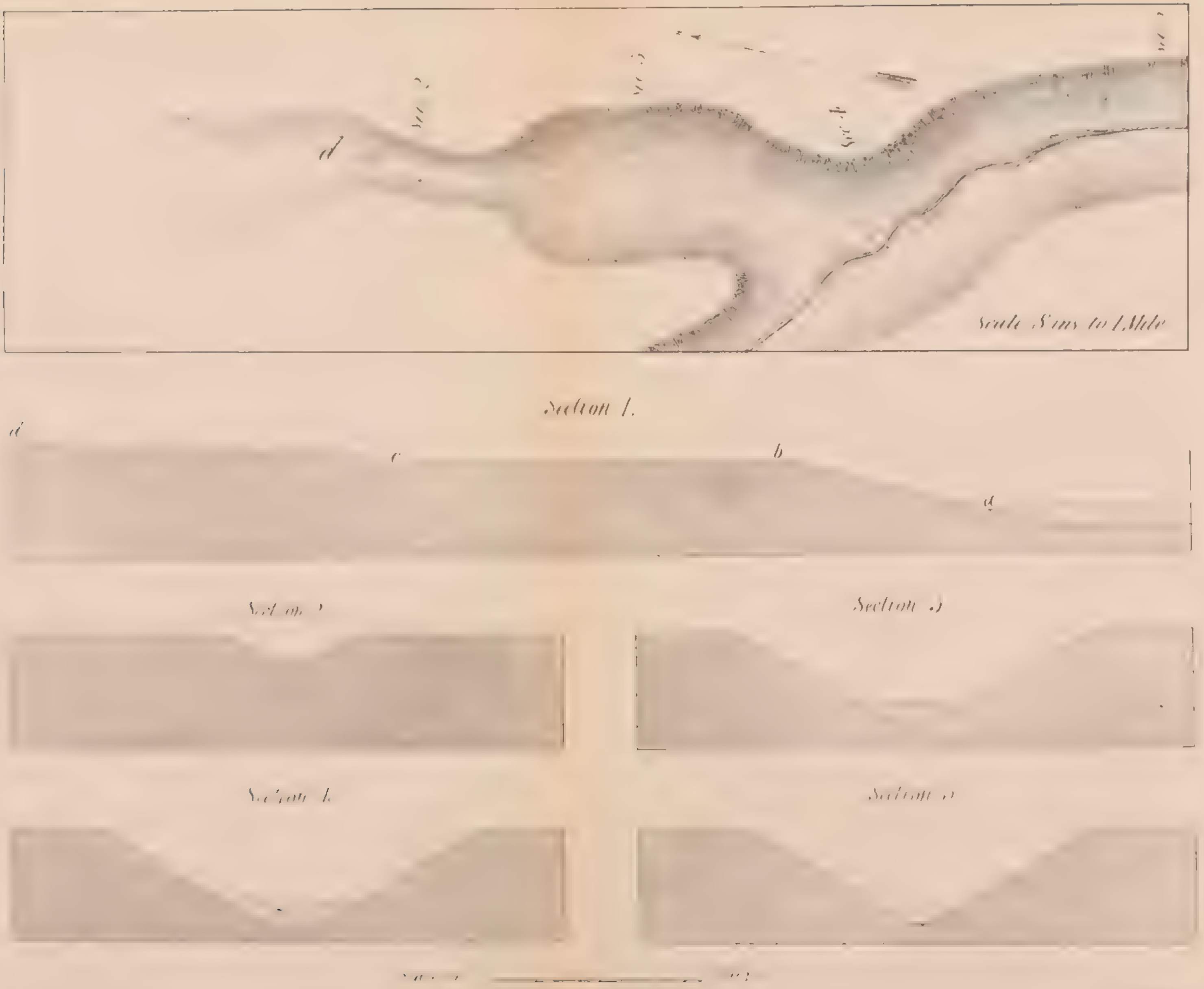
Mr. Ward stated that in his invention the stove is constructed in a vertical position, so as to expose a considerable surface for the absorption of heat from gas burners, and for the radiation of the heat; and that, from the flatness of construction, the apparatus occupies little space, not projecting into the room more than two or three inches, being thus productive of little inconvenience when out of use.

A plate of thin sheet iron is fitted into an ordinary fire-place, in the manner of a fire board, about two inches within the projection of the mantel-piece; about three inches in front of the back plate, a similar plate of sheet iron is secured by bolts; a third somewhat smaller plate of iron is placed about one inch from the second plate, and enclosed at the top, bottom, and sides, so as to form a chamber of about two to three feet square, and one inch in depth. Towards the bottom of the last plate a long aperture is cut, closed by a sliding plate, acting as a door for lighting the gas jets, and admitting a small quantity of air. A little below the aperture a pipe is introduced, in which are fixed three or more gas jets, either the ordinary small bat-wing burners, or burners with two or three holes, so that the flames may extend laterally, not coming into immediate contact with the iron. From the top of the enclosed chamber, a pipe, an inch and a-half in diameter, proceeds through the second and first plates into the chimney of the room.

The Author found that this apparatus was sufficient to raise the temperature of a moderate-sized apartment from five to ten degrees Fahrenheit, with a consumption of about three feet of gas per hour, costing about twopence for ten

III

PLAN AND SECTIONS OF YEDMAN DALE



hours, and that it was particularly useful in warming a bedroom, where only a slight elevation of temperature was required, and perfectly free from the production of dirt or the slightest smell.

None of the products of combustion entered the room, and the ventilation was improved rather than impeded.

ON THE EXCAVATION OF THE VALLEYS IN THE TABULAR HILLS, AS SHOWN BY THE CONFIGURATION OF YEDMANDALE, NEAR SCARBOROUGH. BY H. C. SORBY, ESQ., F.G.S.

The Tabular Hills are a range of flat-topped hills, extending from Scarbro' westwards to near Thirsk. They are composed of coralline oolite, or calcareous grit, at the top, overlying Oxford clay, Kelloway's rock, cornbrash, and the upper sandstone and shales; and their peculiar configuration is very clearly traceable to this structure. The part to which I shall particularly refer is that near Scarbro'. Proceeding from the low flat tract of the vale of Pickering, the surface of the hills rises gradually to the north for some distance, and then the top becomes nearly level, having no undulations, and diversified only by deep-cut ravine-shaped valleys; the configuration and origin of which is the subject to which I wish to call your attention.

The nature of these valleys will be best understood from *Sec. 5*, *Plate III.*, where a portion of the level top will be seen on both sides, and the ravine-shaped valley cut sharply out, with the sides inclined at an angle of 30°.

We have, therefore, in these valleys a case in which it might with considerable propriety be concluded that they had been produced by the action of the streams now running in them, inasmuch as their form is the same as would be produced by such action, continued for a long period. We have, however, in the case of Yedmandale, an association of circumstances that have, in a remarkable manner, preserved phenomena which clearly prove that they are not due to this agency, but to some other not now in action in the locality.

The configuration of that branch of this valley which exhibits these facts will be seen from the accompanying plan. The sides in every part, except those which I shall mention below, are inclined at an angle of 30°, and are quite straight from the top to the bottom, as shown by the sections. In the bottom we have a deposit of loose, coarse, not much water-worn detritus, of local origin, which is not deposited horizontally, but undulated, as indicated by the shading. It is owing to the coarse nature of this deposit, and to the fact of the neighbouring valley of the Derwent being about 300 feet deep, whilst Yedmandale is about 100 feet, that there never has been a brook in its northern arm; for the chief drainage passes into that deeper-cut valley, and what little runs into Yedmandale sokes away amongst the coarse detritus, without forming any brook. We have, however, a stream in the north-western portion of the valley, as will be seen from the plan; which, however, after passing along for some distance, is lost amongst the detritus, in a part below that shown in the plan. *Sec.* 3 is across the northern arm of the valley, in the part indicated on the plan, the steep sides and the deposit at the bottom being shown; the dotted line in this and the other sections indicating the position of the surface before the excavating took place. Passing northwards from this part, it will be seen that the end of the valley is round and amphitheatre-like; the central portion being inclined at an angle of 14°, and each way quickly becoming steeper. Ascending up the centre we come to a small valley with a flat bottom, as shown by *Sec.* 2; and though I could not ascertain it for certain, I think it contains no detritus. The steep sides of this upper valley round into those of the lower one, and gradually vanish away to the north, as will be seen from the plan; the northern part being only a rounded depression, with no flat tract at the bottom. But the most remarkable feature is the small depression at the northern end of the flat tract at the bottom of the upper valley, as will be seen from the plan. *Sec.* 1 is in the direction of the length of the valley, along the bottom, from the point marked *d* on the plan, to a short distance in the lower valley. The above-mentioned depression is shown at *c* of *Sec.* 1; the part from *c* to *b* is the bottom of the upper valley, and from *b* to *a* is the inclination down the centre of the round end of the lower, with the detritus at the bottom. The brook coming down the north-western arm of the valley has cut out a small ravine, and formed some small alluvial tracts in the detritus at the bottom of the valley, as will be seen from the plan and *Sec.* 4; and as we proceed downwards it has removed the whole, and brought the valley into a state in which there is no evidence of its not having been wholly excavated by the brook, as shown by *Sec.* 5, where the lowest dotted line shows the original level of the detritus.

Taking all these facts into consideration, I think no one can imagine that any stream of water, such as now usually runs in such valleys, can have excavated Yedmandale; and from it I think we may safely infer the same of other similar ones in the locality, which, owing to circumstances, do not retain their original structure, but have been modified by the action of the brooks running in them. It is, however, not so clear what other action produced them; and though I do not wish to push theory farther than phenomena clearly lead, I must confess that a strong current from the north, when this part was below the level of the sea, offers a better explanation, in my opinion, than any other that I can suggest; and I would remark that, when on the spot, this view of the subject presented itself to my mind most strongly. The part of all others which, I think, indicates such an origin, is the depression at the top of the small upper valley, which is precisely what a current coming from the north would produce there, as will be seen from *Sec.* 1: for a current coming in that direction, and passing the northern side of the depression, which is double the height of the southern, would have a tendency to scoop out such an excavation, in the same manner as we see in all waterfalls and eddies. Moreover, the large expansion of the valley agrees, I think, better with this supposition than with any other. Whether or no this current was one produced by sudden elevation of land to the north, and was directly connected with the erratic drift which is found in such large quantity in the neighbourhood, would be a problem of interest, but one which, I fear, would take up too much time to discuss. I might, however, remark, that I think it is more probable that it was excavated, and even laid dry to a certain extent, previously to the time when the chief part of the erratic drift was deposited; for, as far as I could ascertain, the detritus in this and similar valleys in the neighbourhood is entirely of local origin. On the contrary, the erratic drift appears to be confined chiefly, if not entirely, to a lower level, as though some portion of the higher lands had been above the level of the sea.

I will not, however, enter farther into this subject, for I am most willing to confess that I think there are many serious difficulties to contend with in adopting any theory whatever to explain the mutual connexion of all the phenomena associated together in the neighbourhood; though I am of opinion that the supposition of there having first been a wave of translation from the north, and subsequently drifting by means of ice-bergs, agrees with the whole phenomena better than any other.

ON FUEL—ITS NATURE, VALUE, AND APPLICATION. BY W. L. SIMPSON, ESQ., C.E., THURNSCOE HALL, DONCASTER.

Although England has derived great part of her national glory from the fact of her being situated near the centre of the earth's civilization, and from her insular position affording capabilities for commerce which the extreme richness of her soil enables her to originate and support, yet there is one condition of her political power, the absence of which has caused nations, otherwise similarly endowed, to fall far short of our own both in agricultural and manufacturing development.

This condition it is my object in this paper to bring in detail more prominently before you. I allude to the existence of large, almost illimitable, resources of *fuel*. Whether the processes of manufacture, the operations of agriculture, or the facilities for speedy transit of manufactured products from different parts of our own, or the most distant of foreign countries, are conceived to be the chief agents in the advancement of our national prosperity, in all and each we cannot but recognise the absolute necessity, everywhere so strikingly manifest, of an abundant and economical production of artificial heat. In nature, heat appears as an universally distributed vivifying and fructifying principle; and in art the elimination of force is almost equally dependent on its presence.

The following remarks will, however, illustrate more clearly the different applications of which it is capable. I propose first to consider the *nature* of the different fuels in common use; and, secondly, to ascertain the relative economic value of each, concluding with deducing from such values a few practical suggestions on improvements of which our present system is capable.

First, then, let us examine the nature of *Wood* as a fuel.

Wood, which is a vegetable substance, whose ultimate composition is carbon 36, hydrogen 22, oxygen 22, is composed of three distinct constituents—first, woody fibre; second, a compound of carbon, hydrogen, and oxygen, which forms the cellular tissue in which resides the sap; and, thirdly, water. The composition of dried wood may be taken (on the average of several analyses) as carbon 50, hydrogen 6, and oxygen 44. The woody fibre and the sap are supporters of combustion, which the remaining constituent, water, deteriorates. The quality of wood, therefore, as a combustible, depends on the quantity of water it contains; but it cannot be said that those woods which contain the greatest amount of carbon are the best for combustion, as the lighter woods, whose sap is of a more resinous nature, usually burn more readily, and cause a greater elimination of heat. Wood is but little used as a fuel in this country, its rapid combustion and the small amount of heat and flame it affords, having prevented its adoption, except in cases where the prevalence of extensive forests, as in America, have rendered it the most economical fuel. In the lowlands of Lincolnshire, however, the remains of the ancient forests cut down by the Romans during their invasions of England, which have been preserved by the antiseptic properties of the peat water, rich in protoxide of iron, form a local magazine of fuel which is sufficient, not only for fencing in the lands, but also very serviceable, from its easy combustion and the brilliancy of its flame, for the fires of the adjacent dwellings. The practical experiments recently made on the evaporative power of wood, give results as low as 3.097 and 3.086. But the difference between these and the figures given by other chemists arose, probably, from the smallness and dampness of the wood employed, and the necessity of a quick draft to carry off the large volume of smoke evolved.

We will next consider *Peat, or Turf*, as a fuel. Peat consists of decayed plants accumulated through a number of years, and compressed into a compact form by the weight of successive layers annually superimposed. When on a retentive soil, the flatness of the land or temporary obstructions prevent the outlet, and cause the consequent stagnation, of water, the area will soon be overgrown by water plants of all descriptions, as the sedges, rushes, algæ, mosses, &c. A species of moss, called spagnum, having the property of throwing up new shoots on its upper part, while its lower extremities are decaying, is the principal plant found in such situations. These plants, during the winter, die and fall to the ground, making room for another crop in the ensuing spring. The constant succession of this process produces a vast accumulation of decaying organic matter, which evolving carburetted hydrogen, (C_2 H_4) carbonic acid (CO_2), and olefiant gas (C_4 H_4), and other noxious gases, and taking up oxygen from the surrounding water and soil, assumes the form familiar to us by the name of peat. The superposition of Kimmeridge upon Oxford clay, without an intervening porous stratum, is the most favourable locality for its formation, and is well exemplified in Lincolnshire, where such an order of stratification actually exists. The nature of peat varies with its geological age, and may be divided into recent peat, exhibiting still the roots and stems of the plants from which it was formed, very porous, and of a light fibrous texture; and the older peat, reposing below this, in which the fibrous merges into an earthy texture, and of which the weight of a cubic foot varies from 50 to 80 lbs., while the former weighs only 4. The composition of peat varies extremely with its age, density, and the locality from which it is obtained. The general result of its analysis gives, carbon 57, hydrogen 6, oxygen 32, and 5 of ash. The proportion of carbon is evidently greater than in woody fibre, the peat during its decay evolving its hydrogen and oxygen, and becoming gradually more rich in carbon. We will examine the nature of this change more in detail when we come to the consideration of the coal formations. Peat is extensively used as a fuel in Ireland and parts of Germany. In the latter country it is merely cut by the spade into the form of bricks, and dried, the surface soil and peat having been previously removed. In Holland, where the peat is an older formation, it is moulded and pressed into bricks by a process almost identical with the manufacture of bricks from clay. The objections to the use of peat as a fuel are its extreme lightness, porosity, and brittleness, together with the quantity of water and ash it contains. 100 lbs. of peat contain from 1 to 33 lbs. of incombustible ash, derived from the vegetable matter of which it is composed. In Ireland attempts have been made to render the peat more portable and solid by compression in powerful hydraulic presses. The peat thus subjected to pressure loses nearly one-third of its weight of water, and from the increased aggregation of the particles of carbon, contains, in a like bulk, a much larger proportion of combustible matter. But the economic value of the peat is not sufficiently improved to counterbalance the expense of so costly a process; as the peat is not even then sufficiently rich in carbon to admit of its general adoption, especially for steam purposes.

A patent has, however, been obtained by a Mr. Hill, for distilling dry peat, and collecting the pyroligneous spirit and tar. The tar is converted into pitch, which he mixes while hot with peat charcoal, and thus renders a very bulky, and, for many purposes, valueless article, one of great importance.

Peat Charcoal is prepared in two ways. First, in circular mounds formed by arranging from 700 to 1,000 brick-shaped masses of peat in concentric layers round a central stake, with apertures to admit the air on all sides, the whole being covered with earth or charcoal dust. Or it is prepared in furnaces of masonry formed like large vertical cylinders, having apertures to admit the air, furnished with regulating valves at the sides. The objections to the use of peat, however, avail equally against the adoption of charcoal made from it, namely, its extremely loose, brittle character, and the quantity of ash it contains, the percentage of which, originally great in the peat before charring, becomes, of course, greater in the charcoal. Ordinary peat charcoal has been known to contain as much as 21 per cent. of ashes. The formation of patent fuel from it will, however, give additional consolidation to the charcoal, and the oleaginous compounds with which the mixture is effected impart a greater degree of combustibility to the mass.

We have hitherto been considering fuel of comparatively modern origin. But the present organic world has contributed but a small share to the support of artificial heat. The wants of man in this respect were as amply provided for by Providence during the primeval ages of the world as his other requirements, more apparently, but not less really, important.

The limits of this paper compel me to abstain from entering into the most interesting question of the ancient structure of our globe. Whether it was by the action of aqueous or igneous causes that the vast disturbances and transformations, the marks of which the crust of the earth now exhibits, were originally occasioned, is not now to be determined. But geology has demonstrated that the most marked and hidden changes of the climate and the position of the terrestrial portion of our planet have been amongst the most frequent phenomena of ancient times. The fossil remains, both in the animal and vegetable kingdoms, point with undeniable clearness to the fact of the existence of a climate in the northern hemisphere differing widely from the present, and more analogous to that now existing in the tropics. The gigantic calamites, lepidodendra, sigillariæ, and stigmariæ, fed by the rich soils which no previous vegetation had impoverished, and fostered by the uniform warmth and humidity of the climate, formed at that time a mass of vegetable life of which even our tropical forests convey but a faint idea. In endeavouring to account for this fluctuation of climate, I have been led, after a careful study of the evidences hitherto adduced, to reject the theory of astronomical causes being a principal or even a minor agent. The mean amount of solar radiation being in the inverse ratio of the minor axis of the sun's orbit, would vary, of course, with the eccentricity of that orbit; but the lapse of years required before such eccentricity would be sufficiently great perceptibly to influence the climate of our planet, renders it difficult to conceive that geological changes of such magnitude could be effected by it.

It was formerly supposed that the plants of the carboniferous era were so closely allied to tropical genera, and so much larger in size than the corresponding tribes now inhabiting equatorial latitudes, as to imply an extremely hot as well as humid and equable climate. Recent investigations have, however, shown so wide a difference between past and existing species, that we must rather infer the existence of a climate more equable, but essentially different from, rather than analogous to, any existing climate. The evidence strongly points to the existence of a more uniform and temperate climate, rather characterised by the absence of any severe cold, than by the presence of extreme heat. I am not now going to discuss the probable cause of such a change of climate, but I would express a strong conviction that the elevation and depression of large tracts of land, and a corresponding variation in the ratio of land to sea in the northern hemisphere, has been a principal agent, assisted, as it necessarily would be, by a consequent change in minor physico-geographical phenomena. The hypothesis that those vast masses of vegetable remains which form our coal fields have been transported from foreign climes by the overwhelming agency of large bodies of moving water, cannot, I think, be maintained, when the position of the flora, and the angular shape and large size of the particles of rock with which they are associated, are accurately observed. The rich supplies of carbonic acid from the atmosphere, and the fresh unimpaired soils of the period, formed the sustenance of vast forests which flourished for a long series of years with extraordinary vigour.

The districts, however, whose elevation above the sea level had introduced such remarkable modifications in the climate, rested on no secure foundation, and during subsequent disturbances seem to have been again submerged. The existence of the alternating freshwater beds of coal and strata, from the shells they contain, evidently marine, indicates that these convulsions were more gradual than the preceding elevations; and that while the depressions appear to have been local, and the area of water confined to the valleys, the mountains and higher lands projecting above the sea formed an ocean studded with islands. These islands, after the erosion of their sides had furnished material for the marine deposits alluded to, again, by a series of gradual elevations and depressions, assumed the form of a new and vast continent, whose soil, vegetation, and climate, had been transformed into our own. The ancient forests, thus imbedded in the marine deposits with which we now find them associated, underwent a process of eremacausis or decay, varying in its nature with the depth of the superincumbent strata, and the corresponding presence or absence of the atmospheric oxygen. In the more recent tertiary strata, we find what is usually termed the *wood coal*, or *brown coal*, of Germany, during the formation of which the air has not been entirely excluded.

The essential change in the conversion of wood into brown coal seems to be the separation of carbonic acid from its elements, while a portion of hydrogen is removed by oxidation, owing to a limited access of air.

For if from wood, whose composition is	$C_{36}\ H_{22}\ O_{22}$
We take one atom of hydrogen, and three atoms CO_2 …………………	$C_3\ H\ O_6$
There will remain brown coal …………	$C_{33}\ H_{21}\ O_{16}$

The separation of carbonic acid is even now going on, as evidenced by the acidulous springs found in the neighbourhood of such beds, and by the presence of choke damp (carbonic acid) in the mines.

Mineral coal, however, which occurs in the secondary or primary formations, appears to have resulted from the long-continued decomposition of wood, or wood coal, without access of air; the separation of carbonic acid (CO_2), water ($H\ O$), and carburetted hydrogen ($C\ H_2$), being the result.

For if from wood ……………… =	$C_{36} + H_{22} + O_{22}$
We take 9 equivs. (CO_2) ……… =	$C_9 \qquad + O_{18}$
	$C_{27} + H_{22} + O_4$
3 equivs. water ………………… =	$H_3 + O_3$
	$C_{27} + H_{19} + O$
3 equivs. carburetted hydrogen … =	$C_3 + H_6$
There remains mineral coal, whose composition is ………………	$C_{24} + H_{13} + O$

Or if the composition of wood be taken, as it is by some chemists, as $C_{36}\ H_{44}\ O_{22}$, then the resulting coal will have a composition of $C_{24} H_{26} O$. The rapid evolution of carburetted hydrogen in situations where its escape was previously impossible, has frequently caused the fearful explosions so often following the opening by the miners of cavities in the coal strata filled with carburetted hydrogen, liquified by pressure.

The older the formation of coal, the more is its composition analogous to pure carbon, till we arrive at last at the anthracitic beds, which, as I have before noticed, contain extremely little hydrogen or oxygen.

The coal formations may, therefore, be divided into three classes:—

1st. The coal formation, subdivided into the older (anthracite), and the younger coal formation (coal).

2nd. The secondary formations found in the neighbourhood of the chalk.

3rd. The tertiary formations, consisting of alternations of brown coal with freshwater limestone.

In the latter or tertiary formations the coal still retains all the forms of its vegetable origin, consisting generally of the flattened stems and leaves of ancient plants. It possesses no peculiar excellences as a fuel, yielding on an average from 3 to 7 per cent. of ashes, 60 to 70 per cent. of carbon, 4 to 6 of hydrogen, and 18 to 36 of oxygen. Its combustion is not attended with a good flame, and though much valued in Germany, where fuel is comparatively rare, would be considered as of very inferior quality in England.

Mineral coal, which we have next to consider, is so well known that I shall only remark, that it may be divided into fibre coal, appearing in thin layers, parallel with the plane of stratification, richer in carbon than the rest of the mass; pitch coal, associated with bituminous hydro-carbons; and slate coal, so named from its fissile nature.

A mixture of iron pyrites (sulphuret of iron $Fe\ S$) is frequently found in coal, and is very objectionable, from the action of its sulphur on the iron bars of furnaces, &c.

Coal yields from 1 to 30 per cent. of ashes, but usually less than that obtained from peat or brown coal. Its specific gravity is about 1.3 on the average. Anthracite, a common formation in the older series in Wales, is eminently homogeneous, and without impressions of plants, and consists almost entirely of carbon; the amount of its ash varies from 1 to 6 per cent.

Time will not admit of my describing now the varieties of fuel resulting from subsequent artificial preparation of these natural fuels, as coke, charcoal, &c. I cannot, however, pass over the subject of patent fuels. The brittle nature of our coal deposits, and the difficulty of combustion attending coal so mechanically divided as to exclude the free circulation of air, has caused the accumulation of vast heaps of small coal at the mouths of our coal pits. Several patents have recently been taken out proposing to convert this, by various processes, into a useful and economical fuel. The most extensively employed of these patent fuels is that of Mr. Wylam. A brief sketch of this fuel, with the results of experiments on its composition, will suffice to give a general idea of the whole.

He first distils *coal tar*, in a large iron retort, furnished with suitable condensers, into *naphtha*, *dead oil*, and *pitch*. The naphtha being the most volatile, passes over first, and is re-distilled at a temperature of 212° by steam, and after admixture with chloride of calcium ($Ca\ Cl$) or quick lime ($Ca\ O$), and a third distillation, becomes perfectly colourless and fit for sale. The dead oil obtained as the second product of distillation, is used extensively for the purpose of illuminating manufactories and other large works; as a solvent for pitch, thus forming a valuable varnish; and lastly, by being burnt in long galleries, it forms large deposits of a most excellent lamp black. The residue, (pitch,) when cold, is ground, and mixed with small coal in the proportion of 1 to 4, and having been again heated, is cast into brick-shaped moulds, and subjected to an enormous pressure. The composition of one of these bricks was carbon 76.60, hydrogen 5.15, nitrogen 1.54, oxygen 9.63, ashes 7.08, in 100 parts; while another specimen more accurately analysed gave from 79 to 80 per cent. of carbon, and from 4 to 5 of ashes.

These patent fuels have many great advantages, and some qualities equally prejudicial. Their form, that of equal-sized cubical bricks, renders them well adapted for stowage; for although the specific gravity of patent fuel is lower than that of ordinary coal, from their shape and mechanical structure, there are few coals which could be stowed away in a smaller space per ton. When examined in the Admiralty coal investigation, the three patent fuels of Warlich, Wylam, and Bell, ranked among the highest result obtained, and in the order named. For the purpose of the steam navy, however, the dense black smoke they evolve during combustion is extremely inconvenient, betraying, as it does, the position of ships of war at a time when it is most important to preserve concealment. This, added to the fact that the bitumen they contain renders them liable to spontaneous combustion in hot climates, has hitherto prevented their meeting with the notice they deserve. Errors in their manufacture are frequent, as the mixture of bituminous or tarry matter with bituminous coal, instead of with anthracitic, as theory would point out; and in some varieties the addition of large quantities of lime, salt, clay, and other incombustible matters, has occasioned the production of so great an amount of ash as to prevent their application to any economic purpose.

Having, then, discussed briefly the nature of the different fuels in common use, we are now in a position to examine the effects of heat upon them. All fuels are of very complex constitution, and it is a law of organic chemistry that the greater the complexity of a body, the easier is its decomposition effected. In bodies so compounded the effect of decomposition is usually a disturbance of the existing equilibrium of the elements, and their re-arrangement into new compounds. The nature of these compounds depends on the external circumstances with which the decomposition is attended, and on the presence or absence of oxygen. The action of heat upon fuel exhibits instances of decomposition of both kinds. The first process is a dry distillation of the elements of the coal without access to air. It is erroneous to suppose that the combustion of fuel is caused by the direct action of atmospheric oxygen on the elements themselves. The hydrogen and oxygen of the fuel, on the application of heat, abandon their former state of equilibrium, and form new products with the carbon, the superior affinity of which prevents the formation of more water (HO) than the equivalent of oxygen and hydrogen in the coal admits. We have, therefore, first, the oxygen uniting with the hydrogen to form water, and then the excess of hydrogen (which there always is in coal above the quantity required to form water with the oxygen) unites partly with the nitrogen, and forms (NH_3) ammonia, and partly with the carbon, whose equilibrium has been disturbed by the movements of the other elements; carburetted hydrogen ($C_2\ H_4$) and olefiant gas ($C_4\ H_4$) resulting. These binary compounds again acting chemically on each other, give rise to an endless series of ternary compounds of small economic value, of which the principal are acetic acid, pyroxylic or a wood spirit, naphtha, naphthaline, paraffin, picamar, kreosot, kopnomor, and pitacall. The second process is the combustion of these products of distillation, and it is this which causes the evolution of heat, and the illuminating powers of the fuel. There is, however, no heat lost by the previous distillatory process, as, although there is an immense amount of latent heat absorbed in rendering these products volatile and gaseous, it is exactly counterbalanced by the quantity of heat eliminated by their subsequent combustion.

An augmented proportion of hydrogen in a fuel, accompanied, as it usually is, by a corresponding deficiency of oxygen, increases the number and quantity of the hydrocarbons evolved, and has frequently the effect of causing the fuel to cake into solid lumps, choking up the bars, and preventing a due supply of air to the fire; while, on the other hand, anthracite being, as we have seen, almost pure carbon, evolves so few hydrogenised products, as not to soil the whitewashed fireplaces and chimneys in which its combustion is effected.

Let us now pass on to consider the relative value of fuel. And first, let us endeavour to discover the principles governing the maximum theoretical value of each. To accomplish this we must take into consideration, first, the quantity of heat which a certain amount of fuel is capable of producing; and secondly, the time which is required for that object.

The experiments of Lavoisier and Laplace on this subject have warned us that it is the relative, and not the absolute, quantity of heat produced by different fuels which we must seek to ascertain. Attempts have been made to establish this by the aid of calorimeters, which, by registering the quantity of ice melted, or the difference in the temperature of water occasioned by the combustion of a given quantity of each fuel, rendered the calculation of their respective heating values easy. There are, however, other more convenient methods grounded on the law enunciated by Laplace, that those quantities of a combustible body which require an equal amount of oxygen for combustion, evolve also an equal quantity of heat. The oxygen required in the combustion of a fuel thus becomes a standard by which its relative heating value can be deduced.

That greatest of modern chemists, Berthier, has founded upon this law a practical process as follows. A weighed quantity of the fuel very finely pulverised is intimately mixed with about 1,500 grains of litharge (oxide of lead, Pbo), and the whole introduced into an earthen crucible, the cover of which is luted down with fire clay, and, when dried, allowed to remain about fifteen minutes in an assay furnace, with a moderately strong fire. The combustible will reduce a certain quantity of the oxide of lead to metallic lead by uniting with its oxygen, in the same manner in which a body burns in atmospheric air by the abstraction of its oxygen. The number of equivalents of oxygen required to effect such combustion will, therefore, be accurately indicated by the number of equivalents of reduced metallic lead, which can be easily estimated from the weight of the button produced.

According to the experiments of Despretz, 1 equivalent of carbon is sufficient to heat 78.15 equivalents of water from 0° to 100° Centigrade; and as the same quantity of carbon requires 2.666 equivalents of oxygen, which taken from litharge leaves 34.5 equivalents of metallic lead, we have for the result, that every equivalent of lead that is reduced by an experiment with any kind of fuel, corresponds to $\frac{78.15}{34.5} = 2.265$ equivalents of water, which will be raised from 0° to 100°. But this method is merely approximate, and obviously, from the amount of hydrogen in the fuel above what is required to form water with the oxygen not being taken into consideration, very serious error may be introduced. Practical experiments have shown that the determinations made with litharge are always (about one-ninth) short of the truth. An elementary organic analysis is a much more correct method of finding the calorific values.

The theoretical value of fuel, more particularly of coal, with reference to the number of pounds of water which 1 lb. of fuel will convert into steam being given by the formula $\left(\frac{C \times 13{,}268}{965.7}\right) \times \left(\frac{(H-h) \times 62{,}470}{965.7}\right) = x$, in which C is the quantity of carbon obtained from an analysis of the fuel in question, H the quantity of hydrogen, and h the amount of this hydrogen, which corresponds to the oxygen contained in the fuel, these, multiplied by their heating powers, 13,268 and 62,470 respectively, (obtained from the accurate experiments of Dulong), and divided by the latent heat of steam, indicate the number of lbs. of water that can be converted into steam by 1 lb. of coal. It is, however, frequently more convenient to have this number converted into an expression of mechanical force, which can be accomplished thus. Let w represent the quantity of water of which (u) lbs. are evaporated by 1 lb. of coal, then w $u \times 965.7 \times 782 = x$ the actual duty obtained by a lb. of coal, namely, the number of lbs. of water raised by it to the height of one foot. This formula is founded on the fact that (u) lbs. of water, multiplied by 965.7, or the co-efficient for the latent heat of steam at 212° as obtained by Regnault, indicates the number of lbs. of water which would be raised 1° Fahrenheit, and the number 782 arises from experiments on the mechanical force denoted by the elevation of 1 lb. of water 1° Fahrenheit: that force, according to the careful experiments of Mr. Joule, on the friction of oil, water, and mercury, being equal to 782 lbs. raised to the height of one foot.

But in ascertaining the relative value of a fuel, we must take into consideration the specific objects for which the fuel is to be employed. A fuel pre-eminently calculated for steam purposes may be one of the least so for other equally extensive applications. The relative evaporative values of different fuels, or their power of producing steam, are, however, too important to be passed over without special and separate notice. The qualities of fuels, with reference to this point, are so remarkably varied, and the necessary excellences so seldom united in one species, that it becomes difficult to deduce any definite general results. The characteristics essential for steam purposes, having especial reference to the steam navy, may be stated as follows:—

1. That the fuel should burn so that steam may be raised in a short period, if this be desired; in other words, it should be able to produce quick action.

2. It should possess high evaporative power; that is, be capable of converting much water into steam with a small consumption of coal.

3. It should not be bituminous, lest the particles of coal should become cemented together into tough and infrangible cakes, obstructing the passage of air through the bars, and its free circulation through the mass of combustible.

4. It should possess considerable cohesion of its particles, so that it may not be broken into too small fragments by the constant attrition which it may experience in the vessel.

5. It should combine a considerable density with such mechanical structure that it may be easily stowed away in a small space, a condition which, in coals of equal evaporative values, often involves a difference of more than 20 per cent.

6. It should be free from any considerable quantity of sulphur, and should not progressively decay; both of which circumstances render it liable to spontaneous combustion.

7. It should not contain a large per centage of ash.

The best coal for steam purposes should unite all these qualities in itself, but a coal possessing the first and not the fifth may, for ordinary purposes, be equally efficacious.

For upwards of twelve months I was enabled almost daily to inspect the experiments of the Admiralty coal investigation, conducted by Dr. Playfair and Sir H. De la Beche. It would, however, be tedious to enter here into the details of these extensive experiments, but I think it may be profitable to state that the relative evaporative value of each coal was tested by three independent experiments, beneath a steam boiler specially erected for the purpose, and furnished with every contrivance for obviating the perturbating influence of external causes.

The following particulars were attended to and results obtained. For each coal was marked, the time required to get up the steam; the weight of wood therein employed; the initial temperature of the water in the boiler and the tanks; the state of the barometer and dewpoint; as well as the extremes of external and internal temperature; the area of damper open; weight of coals consumed; weight of ashes, cinder, and soot left, and their respective proportions of combustible matter and clinker; weight of water evaporated from 212° by the whole, and each pound of coal per foot of grate surface; together with the duration of the experiment, the specific gravity, mean weight of a cubic foot, cohesive force, and economic weight of each variety of coal operated on.

The general result of these experiments, which were conducted with scrupulous accuracy, was strongly corroborative of the results obtained theoretically; and the following formula, by which the practical results were calculated, may be taken as of very considerable accuracy for coal:—

Let W = the weight of water let down from the tanks during the experiment.

w = weight of water in boiler at the commencement of the experiment.

w' = weight of water in boiler at the close of the experiment.

q = weight of wood used for lighting the fire.

l = co-efficient of latent heat of steam = 965.7.

t = quantity of heat necessary to raise the water in tanks from its mean temperature to that at which it is evaporated.

t' = quantity of heat necessary to raise the water in the boiler from the initial to the final temperature.

t'' = quantity of heat necessary to raise water at the temperature of the tanks to the final temperature of the boiler.

P = weight of coal consumed during experiment.

E = the co-efficient of evaporative power of wood.

E' = co-efficient of the evaporative power of coal.

Then

$$\frac{(W - Eq + w - w')\,l + (W + w - w')\,t + wt' + (w' - w)\,t''}{P\,l} = E'.$$

The relative value of the different fuels, as shown by these experiments, need not be here enumerated. The average result of thirty experiments on coal and patent fuel gave 8.69 as the number of lbs. of water converted into steam by 1 lb. of coal. This quantity, it may be remarked, is far below the theoretical result. There are at present no authentic experiments on other species of fuels, with which these may be compared. I have, however, taken an average of the theoretical value of various fuels, as obtained from the litharge experiments, which will be sufficient to exhibit their relative economic importance.

For different kinds of wood, lbs. of lead reduced by 1 lb. of dried wood	13.4
Do. do. do., wood containing 90 p. c. of Ho.	13.9
No. of lbs. of lead reduced by 1 lb. of wood charcoal	30.9
Ditto varieties of peat (foreign)	14.7

No. of lbs. of	peat charcoal (foreign)	21.1
Ditto	brown coal	19.9
Ditto	mineral coal, as given by Berthier	26.8
Ditto	mineral coal, as by Mr. Phillips	29.8
Ditto	coke	26.2
Ditto	anthracite	29.6

The preceding table will enable us to form a tolerably accurate idea of the relative heating powers of different fuels. I must, however, reiterate the caution that these figures exhibit only an *approximation* to *their* ABSOLUTE calorific values.

We have now to consider the second head into which I divided the relative value of fuels, namely, the influence of the time required by fuel to emit its heat.

The general formula of woody fibre is, carbon 36, hydrogen 22, and oxygen 22, and hence the ultimate analysis of all woods invariably indicates the hydrogen and oxygen as present in the proportion to form water without an excess of either element. It is found, however, practically, that all woods contain an excess of hydrogen, varying in quantity in different woods. Thus, in oak there is an excess of 5.08 of hydrogen, in lime of 13, in deal of 9.50, and in larch of 8.60. This excess of hydrogen, on the application of heat, gives rise to hydro-carbons, the evolution of which diminishes the carbon in the wood, and consequently decreases the residue of charcoal. The first and more rapid stage of combustion, therefore,—the combustion with flame,—is augmented at the expense of the second and more permanent, viz., the incandescence of the charcoal. The quantity of heat evolved may be the same, but the rapidity of its evolution diminishes the value of the fuel as a heating agent, for our arrangements for heating are generally of such a nature as to require time for the heat given off by the fuel to communicate itself to the part to be heated. The harder woods, therefore, are preferable to the softer for general purposes, for although the heat evolved by them is less than that given off by the softer kinds, it is rendered more useful in the furnace by passing off with less rapidity. But the greater intensity of the heat thus rapidly produced by the softer kinds, gives them a direct advantage in some manufactures, as in that of porcelain.

The same remark applies equally to coals, and especially to those which are employed for naval purposes. It is often exceedingly important to be able to get up steam in a short time, and those coals which are admirably adapted for maintaining the fire when raised, are usually found deficient in this respect. A mixture of two coals of opposite properties is the only obvious remedy.

I will now only detain you for a short time while I make a few remarks on the improvements in the development of heat, suggested by the preceding considerations. The destructive distillation of coal, we have seen, is productive of the following compounds,—coke, tar, water, ammonia, carbonic acid, olefiant gas, hydro-carbons, and other inflammable gases. The following quantities are those resulting from analyses of six Welsh coals (one of which was anthracite), coke 85.99, tar 2.02, water 3.33, ammonia 0.18, carbonic acid 1.66, sulphuretted hydrogen 0.08, olefiant gas 0.24, other gases 5.34. Now we have seen that the heat developed during the combustion of the gaseous constituents of a coal is equal exactly to the amount of heat abstracted during their formation.

The existence of this thermo-neutrality corroborates the assertion, that the evaporative value of a bituminous coal is expressed by the evaporative value of its coke. This has been tested at great length, and it is found that the work capable of being performed by the coke alone, is theoretically much greater than the practical effect of the original coal. From this the most useful practical results accrue. The volatile constituents might be separated from the coke, and the latter applied with equal economic effect in our manufactures, without the emission of that smoke which at present is so fatal to the health and comfort of our towns. The volatile combustible substance might, by an enlarged system of gas manufacture, be extensively employed for the development of domestic heat, as well as for illuminating purposes.

The ammonia, which we have seen to be an important product of the distillatory process, is at present discharged into the atmosphere. By the most simple arrangement, however, in the coke ovens, the ammoniacal vapours might be economised, and under the form of sulphate of ammonia form a most valuable commercial article. An ingenious patent has recently been taken out by Mr. Crole, of the Tottenham Gas Works, by which he passes the gas through a weak solution of sulphuric acid; the ammonia in the gas unites with the acid, forming sulphate of ammonia, and the gas, after the separation, is increased five per cent. in illuminating power. The solution of sulphate of ammonia is then evaporated down to dryness, every gallon of the liquor yielding 80 oz. of the salt. It has been estimated that 100 tons of coal, in coking, is capable of producing on the average six tons of sulphate of ammonia, $NH_3, SO_3 + HO$, and the commercial price of that salt for the purposes of a manure is £13 a ton. A still more beneficial process is, perhaps, that of purifying the gas by phosphate of lime, containing some sulphuric acid, as obtained by the action of oil of vitriol upon bone earth. The product,—phosphate of lime and ammonia,—containing some sulphate of ammonia, forms a still more valuable manure than sulphate of ammonia alone.

The application of coal gas for the production of heat as well as light, is one which demands our strictest attention. The heating value of gas is even greater than that of coal, and its application to domestic purposes easy and economical. The separation from it of ammonia by the processes just now alluded to, the removal of naphtha vapour and bisulphide of carbon, which are the chief causes of the unpleasant odour of gas, and the application of all these products to economic purposes, render the gas free from all the objections to which, if used in large quantities, it would otherwise be liable. Its advantages, too, are manifest; the absence of all smoke, and, if properly ventilated, of all deposit of soot, the cheerful brilliancy of its flame, the facility with which the supply can be regulated, and the temperature consequently decreased or elevated, all combine to render the use of gas as a substitute for coal in domestic, as well as in manufacturing establishments, at once practicable and beneficial.

Mr. Appold, the talented inventor of the centrifugal pump, at his residence, near London, has erected a small gas manufactory in one of his outbuildings, and uses its products for every heating purpose throughout his entire premises; and by introducing the gas through a number of small orifices at the back of the grates, he obtains a cheerful and exceedingly warm fire. I may mention that, among other ingenious experiments he has provided each supply pipe with a throttle valve, so delicately suspended as to be opened or closed by the fall or rise of a thermometer placed on the stairs leading to the drawing room; and so admirably can the temperature of the house thus be regulated, that he has assured a friend of mine that it does not vary more than 3° or 4° during the whole year. The opening of a window in one of the bedrooms in a few minutes produces a fall in the central thermometer, which opening the supply valve and admitting a larger quantity of gas, causes an immediate development of a proportionably increased amount of heat. I mention these facts to prove that the practical application of gas as a heating power is not ideal, but absolutely in operation. Nor, I believe, is Mr. Appold's a solitary instance.

One more suggestion, and I will bring this somewhat too lengthy paper to its termination. In the manufacture of iron and other metallurgical and manufacturing operations, the elimination of very large quantities of combustible gases is common. The emission of olefiant gas, carburetted hydrogen, and other hydro-carbons, is daily attested by the immense volume of flames which illuminate the country near large iron manufactories. These gases might by various expedients be collected and applied to heating and illuminating the various buildings connected with the works. In an admirable report published by Chevalier Bunsen and Dr. Lyon Playfair, on the gases existing in iron furnaces, it is clearly demonstrated that one of the largest resources of the country is wasted by the neglect of these important considerations. I do not hesitate to say, that the expenditure of fuel to produce steam power for the blast and other mechanical operations, might be wholly economised by the application of such combustible gases in lieu of it.

In all manufacturing processes we are too apt to attend solely to the production of one commercial article, and to neglect others which necessarily arise during its formation. But in these days, when a vast struggle for superiority in commerce and in agriculture, in manufacture and in science, is shaking all European nations to their foundations, the importance of any, even the smallest, bye-product, cannot be overrated; and it should be the object of the manufacturer to discover the whole of the compounds eliminated, and by applying each to its respective purpose, equalise the expense of the generation of all. I might enlarge on the necessity of every manufacturer possessing such a general education in all sciences and all arts, as to enable him to observe what the uneducated, and consequently prejudiced, man would allow to pass by him every day unnoticed; but I will conclude, hoping, at some future time, to follow up the suggestions I have ventured to make, by a more detailed inquiry into the processes of illumination.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FORTY-SECOND MEETING, HELD IN THE CUTLERS'-HALL, SHEFFIELD, ON THURSDAY, JUNE 5TH, 1851.

Alderman THOMAS DUNN having taken the Chair, the following gentlemen were elected Members of the Society:—

W. H. JEFFCOCK, Esq., Sheffield.
H. C. SORBY, Esq., Sheffield.
THOMAS WILSON, Jun., Esq., Sheffield.
JOHN JEBSON, Esq., Huddersfield.

The CHAIRMAN, after addressing the Society in a short speech, called upon Mr. SORBY to read the first paper:—

ON THE MICROSCOPICAL STRUCTURE OF THE CALCAREOUS GRIT OF THE YORKSHIRE COAST. BY HENRY CLIFTON SORBY, ESQ., F.G.S.

The calcareous grit is a sandstone containing a variable quantity of carbonate of lime, which lies just below the coralline oolite. Good sections of it may be seen at Filey, Gristhorpe Bay, and Scarborough. A great part of it is only a sandstone containing a variable quantity of calcareous matter, but a considerable portion contains a great deal, and is much hardened by the infiltration of agate, which has silicified many of the shells and the wood, and filled the chambers of many of the ammonites. It is to this part of the bed that I wish to call attention.

If a piece of it be dissolved in hydrochloric acid, we obtain portions of agatized shells, and a quantity of sandy matter, which, without further examination, would naturally be thought to be merely sand, and such it has hitherto been considered. When, however, examined with a microscope, it is at once seen to contain a very large quantity of reniform bodies, which are evidently not sand, but some kind of minute organisms converted into agate. The mere occurrence of minute agatized shells in this deposit would certainly not be a fact worthy of being laid before this Society, but since they exist in such vast numbers as to constitute a very considerable portion of a well-known rock, and, by the manner in which they occur, are presented to us in a form that is additionally interesting, perhaps a detailed account of them will not be thought a subject unworthy of attention.

The chemical composition of a specimen containing no large shells was determined by dissolving in it hydrochloric acid; and the fine muddy matter was separated from the coarser sandy portion by suspension in water and decantation; from which I found that we had in 100 parts—

Matter soluble in hydrochloric acid, being chiefly calcareous	60
Coarse sandy matter	34
Fine sandy matter	6
	100

This coarse matter consisted, in nearly equal proportions, of the reniform agatized bodies and sand, whose particles varied in size from $\frac{1}{100}$th to $\frac{1}{2000}$th of an inch, the average being $\frac{1}{200}$th, of which the great bulk was composed. The fine matter contained some few grains of $\frac{1}{700}$th to $\frac{1}{1000}$th of an inch, and all sizes down to $\frac{1}{100,000}$th or less, but the bulk was made up of those of from $\frac{1}{10,000}$th to $\frac{1}{20,000}$th of an inch. Hence it is clear that this deposit was not subjected to much washing at the time of its deposition, or else it would not have been composed of particles of such very varying magnitude. Although in some parts the coarse

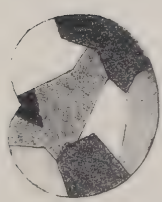
PLATE IV.

1

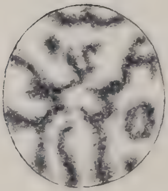
2

3

4

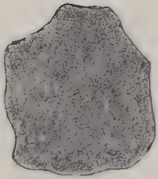


5

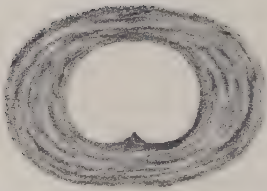


6

7



8



H. C. SORBY. DEL ET LITH.

sand and reniform bodies occur in such numbers as to touch one another, and although some portions of the grit retain their figure when the calcareous matter is dissolved away, yet in others it may be seen that a considerable part of it was deposited at the same time, and was not merely infiltrated among the coarser particles subsequently, although much of it has undoubtedly been introduced in this manner.

If a thin slice of the stone be prepared, not much thicker than $\frac{1}{1000}$th of an inch, and examined with a microscope, the manner in which the grains of sand and the reniform bodies are imbedded in the impure calcareous deposit is well seen. The form of these bodies, however, is best made out by examining them as left after dissolving a portion of the stone in acid, when it will be seen that they vary somewhat in their shape. In many cases they are of a form that may most truly be termed reniform,—one side being perfectly rounded, and the other having an incurved depression of varying depth; in some so slight that the body is almost globular, as shown by *Fig.* 1, *Plate IV.*, which, as well as all the rest, except *Fig.* 8, is magnified about 200 times linear. When turned round, they are seen to be more or less depressed, and to have an oval form, both sides being symmetrical, as shown by *Fig.* 2. Their size varies from $\frac{1}{150}$th to $\frac{1}{400}$th of an inch, the average being about $\frac{1}{200}$th. Their internal structure is best seen by mounting them in Canada balsam, which, having nearly the same refractive power as the agate, causes the light to pass through them as regularly as if we had a thin section. I have also carefully investigated it by examining them in the latter condition, as occurring in a thin slice of the stone. By these means I find that they often have a structure similar to that frequently seen in large agates, the deposit having begun from the sides, and left a vacancy in the centre, which was afterwards filled up with less pure agate in alternating, more or less coloured strata, as shown by *Fig.* 3. It is only in some cases that this sort of structure is well seen by transmitted light; but when a thin slice is examined by reflected light, it is seen much more frequently, owing to the circumstance that many, in which it is really present, are occupied with colourless agate, and, under the former condition, do not, therefore, exhibit their component layers. In some few rare instances there is a vacant space left in the centre, owing to this last stage of agatization not having occurred; and often the whole is filled with homogeneous agate. There are also cases where there is more or less of granular impurity in them, either disseminated or collected together.

But not only are these reniform bodies converted into agate, but also very frequently are entirely filled with calcareous spar. The difference between agate and calcareous spar is very readily discoverable by their action on polarized light. Calcareous spar, owing to its very intense double refraction, does not give rise to colours in the same manner as quartz or agate, in which the double-refracting power is so much less; but, unless the slice be extremely thin, except when we see portions of its system of rings, the only action which it has on polarized light, is to depolarise it in some positions as white light, and, by rotation, definite neutral axes are found. Thus, if the whole of the reniform body is filled with calcareous spar, having the crystalline particles all arranged in one direction, by rotating it round the beam of polarized light, with the analyser in such a position as entirely to suppress it, in some positions white light will be seen to pass through the whole, while in others the body will appear entirely dark. In other cases the bodies are filled with calcareous spar, which has been crystallized in portions that have their neutral axes inclined to one another at various angles, which gives rise to an appearance similar to that seen in *Fig.* 4; the dark or lighter divisions, of course, changing in intensity by rotation, but retaining their forms, which are angular, and such as would be produced by the infiltration of calcareous spar into a shell. When, however, they are filled with agate, no such effect is produced, but in every position we have the appearance of a white disk, with black bands radiating in an irregular manner from the centre, (as shown by *Fig.* 5,) and changing their forms and places by rotation, whilst the intermediate parts have patches of orange or blue, which properties agree with what would result from such an irregular structure related to the centre as the infiltration of agate would most probably produce. In some cases, one portion is converted into agate, whilst another is calcareous, sometimes in the form of crystalline spar, and at others as a concretion, similar to those sometimes to be seen in the substance of the shells from the grit, which are partially agatized. In these, some of the original calcareous matter still remains in the form of small concretions, sometimes disseminated in the agate, but generally attached to the sides of the shell. In the same slice, and in the same field of view of the microscope, we find some of the reniform bodies filled with agate, and others with calcareous spar; but their relative numbers vary in different parts, in some parts nearly all being agate, and in others calcareous.

I counted in the space of $\frac{1}{280}$th of a square inch, in an average portion of a thin slice, no less than forty of these bodies, and, therefore, on a square inch there would be 11,200; and since they are, on an average, $\frac{1}{200}$th of an inch in diameter, there would be at this rate about two and a quarter millions in a cubic inch. Moreover, taking into consideration those filled with calcareous spar as well as those that are agatized, I shall not be overrating them if I suppose them to constitute 20 per cent. of the whole rock. Calculating on this supposition, and on their being $\frac{1}{200}$th of an inch in diameter, and, therefore about $\frac{1}{13,000,000}$th of a cubic inch in content, there would be about three millions in a cubic inch. Hence I think it may be safely considered that there are two or three millions of them in a cubic inch of the stone, when it does not contain many larger shells.

Having thus described these reniform bodies, and shown in what vast numbers they are found. I will consider what they are. That they cannot be grains of sand is quite certain, when we compare their forms and optical properties. Grains of sand are usually considerably angular, and, when more rounded than is common in the rock under consideration, have a form similar to that shown by *Fig*. 7. When seen by reflected light, if mounted in Canada balsam, they are clear and transparent, and not milk white, like the reniform bodies, and never show anything like the agate structure seen in *Fig*. 3. Using transmitted polarized light, they show a definite single system of neutral axes, giving in some positions the even dark appearance shown by *Fig*. 7, and in others various simple colours of a low order, and never any radiating bands at all like those presented by the reniform bodies, (as shown by *Fig*. 5.)

Those which are calcareous do not appear to be rounded grains of shell or coral, for they are, similarly, much too regular in their form. I have had it suggested to me that they might be calcareous concretions similar to the ovum-like ones of oolite rocks, those which are now agate having subsequently been converted into it. I, however, think that when the characters of oolitic grains are compared with them, there is very good evidence that they are not. In all the oolitic rocks which I have examined, the concretions are composed of alternating concentric layers of more or less impure calcareous matter, formed round grains of sand, fragments of shells or coral, or entire small shells, (as shown by *Fig*. 8.) On the contrary, that with which some of the reniform bodies in the calcareous grit are filled is usually nearly pure, whilst that in the intermediate spaces contains much impurity. In those few cases where that in the reniform bodies contains a little impurity, it does not show any trace of concentric structure, but is in precisely the same state as that in the chambers of the ammonites which occur in the rock. Moreover, oolitic concretions are often very irrregular in their forms, and frequently two or more coalesce, which is the reverse of what is found to occur with the reniform bodies under consideration. I have found, by examining the oolitic portions of the coralline oolite, that they also exist in it, though in no great numbers. In it the difference between them and the concretions is very marked, and they form the nuclei of some of them (as shown by *Fig.* 8, which is one magnified 150 linear,) precisely in the same manner as several species of well-known forms of foraminifera and other small shells. At first I thought that they might be globular siliceous spiculæ of sponges, but after finding some which were filled with calcareous spar, I abandoned the idea, for it does not appear to me at all probable that the siliceous matter could have been removed, and its place occupied by calcareous spar.

I have already stated that these reniform bodies occur both filled with calcareous spar and with agate. This is precisely the same with the ammonites which are found in the rock along with them, and I, therefore, judged that it was probable that they were shells similarly filled with infiltered mineral matter. To ascertain this, it was, of course, necessary to determine whether they originally possessed shells or no. I therefore carefully examined a section of a portion of the rock containing an ammonite filled with calcareous spar, in order to learn what kind of evidence it presented of the former existence of a shell. By examining it by polarised light, I found that where no impurity had entered, there was no trace whatever of the shell discoverable, the whole of it having its crystalline particles arranged in the same direction as the calcareous spar in the interior. Where, however, there was muddy impurity in the interior, the shell could readily be distinguished. Moreover, by examining the ammonites which are agatized, I found that the exterior shell was very frequently distinguishable from the infiltered agate, by being more transparent; but this transparent part was not so thick as the shell originally was, and in some cases did not occur at all. The septa, however, being much thinner than the exterior shell, could not be detected in the agate. These facts, therefore, show that, though we cannot detect any trace of shell in the reniform bodies which are filled with pure agate or calcareous spar, we are not warranted to conclude that it did not at one time exist. On this account I very carefully examined a thin section of considerable size, in order to ascertain whether there existed indications of any of these bodies having been burst in, and whether the arrangement of the impurities introduced by that means afforded evidence of the former existence of the shell.

Although such cases are rare, yet I have found some which unquestionably proved that they had been broken, and from the manner in which the impurities occur, I think that the existence of a shell is rendered very probable. In one instance the section of an agatized reniform body showed that it had been ruptured at one end, and the impurities introduced by that means into the interior are collected in such a manner as clearly to indicate the existence of a shell; a distinct uniform line or space of clear agate occurring between the outer boundary of the reniform body and the extraneous granular matter that partially occupies its interior. In another instance, a section of a calcareous body exhibits a thin layer of fine granular matter following the curvature of the inner surface of the reniform body, and lying within, and at a slight uniform distance from its outer boundary, whilst a straight elongated fragment lies within, and rests its ends against the line of granular matter (as shown by *Fig.* 6). Hence it appears that both the finer matter and the larger extraneous fragment rested originally on the inner surface of a shell that has become crystalline. The thickness of the shell shown by both these specimens was about $\frac{1}{7000}$th of an inch, which is so thin that we could not expect to find any trace of it in the agate, when the septa of the ammonites are obliterated. These facts, I think, indicate that these bodies were small shells, whose interiors have been filled with calcareous or siliceous infiltrations, in the same manner as the chambers of the ammonites which are found in the rock. Nevertheless, I will not insist on this view, for I have found cases where the impurities were not arranged as if there had been a shell, though not in a manner irreconcilable with that supposition; but, on the whole, I should say, that there is better reason for thinking them to have been shells, than any other bodies with which I am acquainted. If really shells, they may perhaps have been *Foraminifera*, although I have not been able to detect any internal divisions into chambers, nor anything to indicate that they are detached foraminiferous cells, such as are sometimes met with.

Besides the reniform bodies, we find in the matter left undissolved by acid several other minute agatized organic bodies, which it may, perhaps, be as well to describe. There occur minute cellular bodies (zoophytes?) formed of more or less oval open cells, concave on one side and convex on the other, placed end to end, and communicating at the extremities, in a similar manner to what is seen in the section of a *Nodosaria*. The cells are frequently irregular, and vary much in form; two or more rows being often placed side by side, and single rows of cells frequently branch off from the main body.

Numerous spiculæ of sponges are also found, the most common of which are simple, smooth, and pointed at each end. Others are bulbed at one end and pointed at the other; sometimes of considerable length, but usually broken. I have also found one much branched, quadrifid, with two or more of the extremities bifid.

In some sections I have observed fragments of a brown colour, apparently vegetable, and having a similar structure to portions of *Algæ*.

ON THE USE OF THE BAROMETER IN COAL MINES, AND A CHEAP FORM OF INSTRUMENT FOR THAT PURPOSE.

BY W. SYKES WARD, ESQ., F.C.S., OF LEEDS.

Mr. Ward commenced by observing that he should not on that occasion attempt to discuss the necessity of using the barometer to prognosticate the state of the air in coal mines, as that had been proved in a paper by Mr. West. His object was to introduce the barometer to prevent accidents in mines. It is not the absolute height at which the barometer stands which will indicate danger, but the amount of diminution of pressure or rarefication of air which has taken place within a given time. Suppose the waste or goaf of a mine contain ten times the cubic capacity of the parts of the mine regularly worked and ventilated, if the barometer fall even as low as 28 inches, so that it fall very gradually, the ventilation may carry away the carburetted hydrogen issuing from the goaf and fissures, and no danger be perceived. But if the barometer suddenly fall one-tenth of an inch, the gas in the goaf would expand one-hundredth part, throwing into the workings one-tenth of its volume, and producing an explosive mixture. To guard against that there should be a regular series of barometric observations taken in each pit, and the record sent to some party who might compare the observations with others taken either in other pits, or by parties keeping a regular register, at a considerable distance. Such comparison of registers would produce an efficient check on the man who had to record the barometric variations. At least four observations should be taken during the twenty-four hours, and whenever any fresh set of men went down to work, so that they might receive timely caution of danger.

The method of recording the variation should be as simple as possible. A slate or piece of board should be furnished, ruled with columns and spaces for each time of observation, and on which the height of the barometer might be marked with chalk, and, for simplicity, it might be advantageous to use Roman numerals, and to make O represent 28 inches, X 29 inches, XX 30 inches, and a simple stroke I for each tenth up to half an inch, then the V, and for one-twentieth a short stroke, thus ı; and on a third line mark the number of tenths by single strokes by which the barometer, at any observation, is lower than the preceding one; thus making the amount of fall appear evident without necessity for much calculation. Thus, if at six o'clock in the morning the reading were 30.25, at noon 30.40, at six o'clock in the evening 29.90, and at midnight 29.40, the table would be as follows:—

6	XX.IIı	
Noon.	XX.IIII	
6	X.VIIII	IIIII
12	X.IIII	IIIII

After exhibiting this method, by which a wholly illiterate man might take and record the barometrical observations, Mr. Ward described a form of instrument that he had contrived, which consisted of a simple tube of small bore, and of thin glass, which he had found rendered the boiling of mercury a comparatively easy operation, and to which need only be added a small bottle of mercury by way of a cistern, and a scale divided into twentieths of an inch, and which would be better done by comparison with a standard instrument than by actual measurement. The whole might then be protected by being inclosed in an iron tube, such as is used for gas. Such an instrument would be sufficient, and might, with a moderate demand, be probably supplied at a cheap rate, say from 10s. to 15s.

Mr. T. D. Jeffcock inquired in what part of the pit it was proposed to place the barometer?

Mr. Ward said that perhaps the best situation would be the place where the candles or lamps were kept, so that it might be seen by the men, and, if necessary, they might receive a caution before they began to work. He wished it to be understood that he was speaking of mines in which exposed lights might, under ordinary circumstances, be used. Where safety lamps were required, the barometer was of no use: every precaution was indispensable, and there might be danger, though not indicated by the barometer.

In reply to another question by Mr. Jeffcock,

Mr. Ward said it would not be necessary to have a barometer in every part of the pit where the men worked, as its object was not to indicate the amount of inflammable gas; it was simply designed to show when the atmosphere was low, that being the time when most gas escaped from the goafs and fissures.

The Chairman remarked that nearly all the explosions in the north had happened in a low state of the barometer after a sudden fall. In this neighbourhood, where a totally different system of working prevailed, explosions had mostly proceeded from an insufficient circulation of air in the goafs or exhausted parts, to dilute the gas as it escaped from the coal, and reduce it below the inflammable point. Of the usefulness of the barometer there could scarcely be two opinions. It was a singular fact, that the illiterate miners know instinctively that a south wind induces bad air in the pits. In this neighbourhood they imagine that the south wind blows through the whole strata, which inclines upwards to the south, and that the mine is thus filled with bad air. But however false in philosophy, being an observation founded on fact, it is practically of use to the miner, because, as a general rule, the south wind is accompanied by a low state of the barometer, and a sluggish circulation of air as a consequence. The barometer, by showing the pressure of the atmosphere, indicates the amount of escape of gas, and induces caution, on account of which it is a very necessary instrument. It was not necessary that the barometer should be kept in the pit at all. The engineman at the top is generally the best educated, and if under his charge any portentous change should occur, he could communicate instantaneously to all parts of the pit.

Mr. Ward.—I do not see the least objection to that.

Some further discussion was continued between Mr. Ward, Mr. Sorby, and Mr. James Haywood, analytical chemist.

The Chairman here called for the last communication announced for the meeting, which was

ON SOME PHENOMENA AND EXPERIMENTS UPON CAPILLARY ATTRACTION. BY MR. T. J. PEARSALL, F.C.S., OF LEEDS.

The leading object of Mr. Pearsall appeared to be to suggest the constant interference of mechanical forces of solids, with chemical qualities of the atoms, as necessary to explain many of the conditions of articles used for comfort and convenience; on which, indeed, their usefulness for the purposes of buildings, clothing, and even for food depended.

Calling especial attention to the action of the surfaces of all solids as exercising mechanical forces, and also rapidly allowing the peculiar influences of heat, light, and electricity, to be absorbed or reflected, and the action also of the surfaces of fluids upon air and gases, he then called attention to the attractions of a surface of liquid, for the surface of a solid body: considering this a force of great and overlooked importance in nature, because called capillary attraction, and usually understood only to relate to exceedingly small surfaces, and hair-like columns of fluids, as the examples of power.

He proceeded to shew that a very large class of unexplained phenomena was referrible to the agency of capillary attraction, a fuller acquaintance with which might lead to the surmounting of many scientific and practical difficulties. The process of carbonizing steel—the penetration of the carbon into all parts of a substance not supposed to be porous—was incidentally referred to, as showing how little is known of some highly important processes beyond the mere results. Mr. Pearsall undertook to show that the force termed capillary attraction, was in that special form no more than a practical definition of a much more general form, exercised not only upon small quantities of matter, but upon a large scale. To exemplify the operation of capillary attraction, recourse was had to a conical glass vessel, terminating in a tube having a bore equal to a human hair. When the vessel was inverted and immersed in water, the liquid, in defiance of the laws of gravitation, rose up into the tube (which was not immersed) to a height of several inches above the water. This was ascribed to the attraction presented to the water by the wetted sides of the interior of the tube. A simpler illustration was also referred to—the placing two flat pieces of glass against each other, and resting the lower edge in water, whereupon a watery film is drawn up between the two surfaces. Having shown the principle of capillary attraction in the well-known case of a single tube, Mr. Pearsall now exhibited it on a large scale. A hemisphere of fine wire gauze was made to float on water, by simply establishing a watery film in all the interstices by means of immersion, the resistance of the film to the inclosed atmosphere being so great as to keep the copper hemisphere afloat, and sustain a pendant weight of one ounce. The converse of this experiment was shewn by filling a wire gauze sphere with water, and keeping it in by the mere strength of a similar film procured by immersion.

It was thus proved that a thin plate of liquid, even water, (and that might be made up of many small plates), possessed a force that could retain imprisoned volumes of air and gases that could not escape, even if assisted by the pressure of liquids in bulk, and that the thin film of liquids could also retain cubic inches of fluids suspended, and on all sides surrounded by the atmosphere. After shewing the importance of this to explain the retention of air or liquids by membranes, and so causing diseases, and of the retaining power exercised by the structure of strata to retain liquid and gases, he shewed an application of this power on the large scale, and, as some might call it, of practical application and suggestion. The experimenter took an ordinary pillow-case, well wetted, and inflated it with atmospheric air, when it was observed that all the interstices of the threads being occupied by water in the form of film, the object, thus rendered to a surprising extent air-tight, became such a resistant buoy as to be capable of floating a person, or several persons, on the water. This expedient, it was suggested, might be resorted to as a temporary float in a moment of emergency; or drifting upon the ocean, to convey a line from a distressed ship to the shore; the only condition requisite to sustain the floating qualities of the buoy being the continued wetness of the surface, which would retain the atmospheric air. Capillary attraction was exhibited in the absorption of moisture by inferior bricks of houses, and by various articles of clothing. This interesting subject was so treated as to render it popular and highly attractive; and it is much to be regretted that there was not a larger company to profit by the results of Mr. Pearsall's philosophical research. A promise was given for a renewal of the subject on a future occasion.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE ANNUAL MEETING, HELD IN THE EXCHANGE-ROOMS, BRADFORD, ON FRIDAY, OCTOBER 17TH, 1851.

In consequence of the indisposition of the Right Hon. Earl Fitzwilliam, F.R.S., President of the Society, Alderman Dunn, of Sheffield, was called to the Chair.

After the election of the Officers and Council for the succeeding year, the annexed statement of the accounts for the past year was submitted by the Treasurer:—

STATEMENT OF THE RECEIPTS AND EXPENDITURE,

From 29th October, 1850, to 17th October, 1851.

DR.	£.	s.	d.
To Balance in Treasurer's hands..	9	14	7½
To Subscriptions from—			
1 Member for 1839 at 10s. 6d...	0	10	6
1 „ 1840 „ ..	0	10	6
1 „ 1841 at 13s.	0	13	0
1 „ 1842 „	0	13	0
1 „ 1843 „	0	13	0
1 „ 1844 „	0	13	0
1 „ 1845 „	0	13	0
8 Members for 1846 „	5	4	0
1 Member for 1846 at 10s. 6d...	0	10	6
9 Members for 1847 at 13s.	5	17	0
1 Member for 1847 at 10s. 6d...	0	10	6
10 Members for 1848 at 13s.	6	10	0
1 Member for 1848 at 10s. 6d...	0	10	6
22 Members for 1849 at 13s.	14	6	0
1 Member for 1849 at 10s. 6d...	0	10	6
42 Members for 1850 at 13s.	27	6	0
67 „ 1851 „	43	11	0
1 Member for 1851 at 10s. 6d...	0	10	6
3 Reports at 2s. 6d. each	0	7	6
	£119	14	7½

CR.	£.	s.	d.
By Printing Reports, &c.	10	0	0
„ Advertising Meetings...........	2	14	0
„ Lithographing Plates...........	2	0	6
„ Expenses of Meetings	3	17	5
„ Collecting Subscriptions	1	9	0
„ Postage Stamps and Postages..	1	5	9
„ Books and Stationery	1	2	2
„ Rent of Museum Room	20	0	0
„ Salary of Assistant Secretary..	50	0	0
„ Map of Yorkshire Coal Field..	1	5	0
„ Sundry Expenses	3	4	7
„ Balance in the hands of Mr. Batman	10	18	6
„ Balance in Treasurer's hands..	11	17	8½
	£119	14	7½

The Chairman then called for the first communication, which was a

DESCRIPTION OF A DIRECT-ACTING STEAM FAN FOR THE BETTER VENTILATION OF COAL MINES. BY JAMES NASMYTH, ESQ., OF PATRICROFT, MANCHESTER.

Mr. Nasmyth began by referring to the disastrous accidents which had arisen from defective ventilation,—within the last two years there having been 190 lives lost in the neighbourhood of Barnsley alone. This wholesale destruction of human life urgently called for an energetic effort to remove the evil. By increased means of ventilation, and thus getting rid of the accumulation of explosive gases, they would be striking at the root of the evil. This had been hitherto done by causing a rarefaction of air in one of the ascending shafts of the mine by means of a furnace burning below. It had, however, been proved that the furnace system of ventilation was deficient, disastrous accidents having occurred in mines so ventilated. Some more efficient means of sweeping away the accumulation of impure air was therefore called for, and Mr. Nasmyth recommended his direct-acting fan as supplying the *desideratum*. Economy was among its advantages: if one-tenth of the coal at present burnt in a furnace to produce direct rarefaction, were burnt under a boiler applied to a small engine for the purpose of working the fan, it would generally produce a much greater effect. Another important advantage possessed by this ventilating apparatus was, that it was above-ground and accessible, instead of being below-ground, as at present. In case of accident they would thus have full means of re-ventilating the mine. At present many hours had generally to elapse, in case of accident, before the mine could be sufficiently re-ventilated to render a descent safe, and probably one-half of the sufferers died a lingering death from suffocation, and not from the immediate effects of the explosion. The steam fan was about to be put in operation near Wakefield, and its simplicity of action recommended it to all who had seen it. Mr. Nasmyth explained the action of the fan by referring to a drawing which he had prepared. On the fan being made to revolve rapidly, the volumes of air contained between the vanes were forced out, while fresh air rushed in to supply its place. He recommended that the steam engine should be placed in direct communication with the fan, and that the engine should have a very short stroke. A speed of 300 revolutions per minute was thus very easily attained, and 20,000 cubic feet of fresh air per minute could be forced into a pit with a fan whose vanes were eight feet in diameter. A fan whose vanes were double the diameter would be amply sufficient to ventilate the largest mine in Britain. The whole apparatus, including steam engine, would cost about £160. With so efficient a means of ventilation, attainable at so small a cost, it would be a disgrace, in these times of civilization, if such wholesale destruction of human life were allowed to occur.

The second communication, being upon an apparatus for effecting the same important object, was read by Mr. Biram.

DESCRIPTION OF THE FAN ERECTED FOR THE VENTILATION OF THE HEMINGFIELD PIT, BELONGING TO EARL FITZWILLIAM, AT ELSECAR. BY B. BIRAM, ESQ.

This fan, which is eight feet diameter and nine inches wide, has eight vanes, which are so arranged that each forms the segment of a screw which revolves in the same plane. The angle of the extremity or outer edge of the vanes is about 23 degrees with the plane of rotation, making the pitch of the screw about 10 feet 10 inches. The area for the passage of air through the fan is about 47 superficial feet, which, multiplied by 10 feet 10 inches, —the pitch of the screw,—gives 509 cubic feet as the *theoretical* quantity of air which would pass through the fan each revolution. The fan makes 110 revolutions per minute, and is worked by the pressure of a column of water 450 feet high, acting upon the piston of a small hydraulic engine, working in a cylinder four inches diameter and one foot stroke. The engine makes 20 double strokes, consuming 21½ gallons of water per minute; so that the power expended to overcome the friction of the machinery and propel the air is equivalent to the weight of the above quantity of water, or 215 lbs. falling through 450 feet per minute, equal to three horses' power nearly. The engine is considered not sufficiently powerful, and it is intended to increase the power; but the passage of the air is also obstructed by a contraction between the fan and the upcast shaft, which will be remedied by a slant drift, nearly completed, for conveying the air direct from the fan into the upcast shaft. At present the circulation is increased by a fall of water issuing from an opening of five square inches area, and a head of three feet six inches from the top of the engine or downcast pit, which it is calculated discharges 120 gallons per minute. The combined effect of the waterfall and fan causes a circulation of 27,700 cubic feet of air per minute. When the fan is not at work, the waterfall alone circulates 12,700 feet per minute, which leaves 15,000 cubic feet due to the effect of the fan. A comparison of the performance of the water employed in each case, and the power necessary to raise it again to the height from which it falls, will be as follows :—

	Gallons.		Feet.	Horse power.
The fan uses per minute......	21½	falling	450	... 3
The waterfall ditto	120	„	450	... 16

Mr. Biram considered that this description of fan passed as large a quantity of air as any that he had seen. It might be fixed in any situation, and connected with any motive power, whether water or steam. Mr. Biram exhibited a beautiful working model of his fan, about a foot in diameter, the experiments with which were perfectly successful. The quantity of air which passed through the fan was (approximately) indicated by an anemometer, and the number of cubic feet per minute was found to be very large.

In the course of the discussion which followed the communications of Mr. Nasmyth and Mr. Biram, the Chairman took occasion to express his opinion that the importance of this mode of working mines could not be too highly appreciated. There was one difficulty, however, connected with this mode of ventilation, which was, to regulate the velocity of the air which was made to pass through the mine so as to make it compatible with the working of the seam of coal. In case of accident in a mine, and the ventilation becoming suspended, the fan was calculated to be of great advantage, as considerable time must elapse before the furnaces could be lighted. He had been pleased with both the papers. They referred to a subject intimately connected with the commercial interest and prosperity of England. Our very existence as a commercial nation depended upon our mineral wealth, and every effort made to diminish the risks run by the miner ought to be received with gratitude and respect.

Mr. NASMYTH pointed out another advantage likely to accrue from this mode of ventilation, in diminishing the high temperature which was known to prevail at great depths; thus promoting the health and comfort of the miner and the productiveness of the mine.

Mr. BIRAM suggested the adoption of a lamp for use in mines, having an opaque back, with a reflector, for the purpose of throwing the light to the point where it was required.

Mr. THEODORE WEST was glad to find the opinion gaining ground that the safety lamp was imperfect, and thought it desirable that this should be increasingly impressed on the miner, that every other precaution might be taken. With respect to the ventilating fan, at the high speed at which it was intended to work, he thought some slight gearing might be necessary.

Mr. Nasmyth now proceeded with his last communication, which, like its predecessor, was illustrated by diagrams.

DESCRIPTION OF AN IMPROVED SAFETY VALVE FOR STEAM BOILERS. BY JAMES NASMYTH, ESQ.

Mr. Nasmyth gave a description of an improved safety valve for steam boilers, and referred to the calamitous boiler explosions which had been so frequent of late, and observed that, as a means of prevention, none was more efficient than a good safety valve. He proceeded to inquire what were the causes of the failure of the ordinary safety valve—wherein was it deficient? The function of a safety valve was to have some part of the boiler which would open and allow the steam to escape on a certain pressure being reached. This object was very simply attained by a valve of the ordinary construction, loaded either by a weight attached directly to the valve, or by a small weight increased in its efficiency by a system of levers. The ordinary safety valve (of which a model was shown) was liable to stick fast, owing to the muddy sediment of the water collecting round the spindle of the valve. In the common construction of valves the conical form was generally adopted. It was thus important that the internal and external cones should exactly coincide, and it was necessary to guide the spindle very correctly into the centre. This arrangement was subject to the inconvenience of the spindle sticking fast on the one hand, or if it were too slack, it would fail to perform its functions. It was highly probable that many accidents had arisen from the safety valve not having acted efficiently. His improved safety valve consisted in doing away with the spindle altogether, and employing the sphere. It was the property of a sphere to fit a circle in all directions. In order to secure the perfect freedom of the valve at all times, *per se*, and without the necessity for the engineman experimenting upon it, he had resorted to a very simple expedient, by contriving that the wave-like action going on in the water should communicate a slightly pendulous motion to the valve, sufficient to prevent its being fixed in its seat. He would do away with the system of leverage, and have a direct weight attached to the valve, and placed inside the boiler, so that the engineman would be unable to tamper with it. This valve possessed another recommendation—that of cheapness, at it could be made for less than the ordinary cost.

Several gentlemen spoke in high terms of approbation of Mr. Nasmyth's safety valve, considering it the most simple and efficient which had come under their notice. A case was mentioned in which the ordinary safety valve, although tried every day, acquired a considerable amount of friction, and several cases were referred to in which it had been tampered with by reckless enginemen. On board a steamer the valve had been tied down, and in another case a man was found to be hanging at the end of the lever! In the case of an accident for which the man was sent to take his trial at York, the spindle was found to be bent, but whether this occurred before or after the explosion, could not be ascertained. Hence the importance of the safety valve being out of the reach of the person having the control of the engine.

Mr. WEST stated that when travelling on a locomotive, if they were behind time, he found that the engineman almost invariably held on to the safety valve, knowing that very little risk was incurred, and that lost time must be made up. He mentioned another case, as showing how precautions, apparently the most effective, may be defeated if men are so disposed. While travelling through Belgium and France, to acquaint himself with the system of railways in those countries, he was much interested in the government steam guage for preventing undue pressure on the boilers. It was self-registering, so that at the end of the journey the amount of pressure at different stages could be seen. The engine-driver, however, by abstracting or adding a small portion of the mercury, could increase the pressure without the register giving any indication of the fact. The register acted, indeed, but only when the pressure was excessive.

The CHAIRMAN was much pleased with the improved safety valve, and thought it approached as near perfection as possible.

Mr. NASMYTH stated that six of these valves had been in action about eight months at the Oxford Road Twist Company's works, Manchester, and that the managers were most willing to receive the visits of persons interested.

ON THE CONTORTED STRATIFICATION OF THE DRIFT OF THE COAST OF YORKSHIRE. BY H. C. SORBY, ESQ., F.G.S.

The contorted stratification of the drift appears to have been little noticed or understood, until prominently brought forward by Sir Charles Lyell, in a paper read before the Geological Society in 1840, and subsequently published in the Philosophical Magazine. He then suggested that those seen on the coast of Norfolk had been produced by the action of stranded icebergs; but the disturbed condition of the chalk has led many geologists to hesitate in adopting that theory. Since then the subject seems to have been much overlooked, so much so that, when the origin of the drift was under discussion at the meeting of the British Association last year at Edinburgh, no mention whatever was made of the contortions; and yet, as I hope to show, they are of such a character as to be of great value in

FIG. 1.

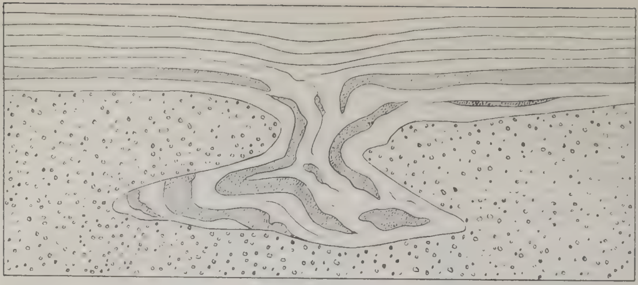


FIG. 2.

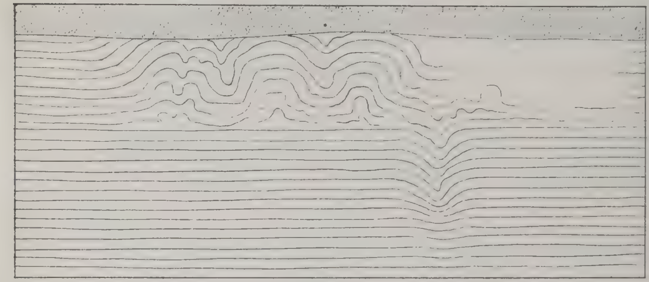


FIG. 3.

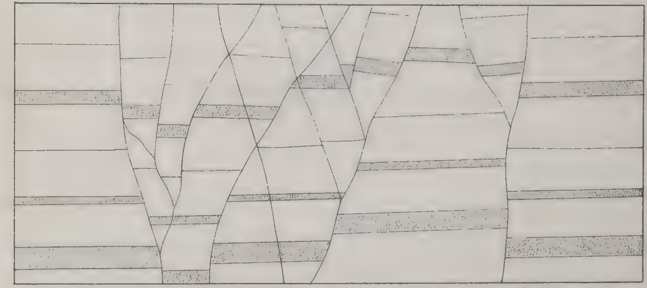
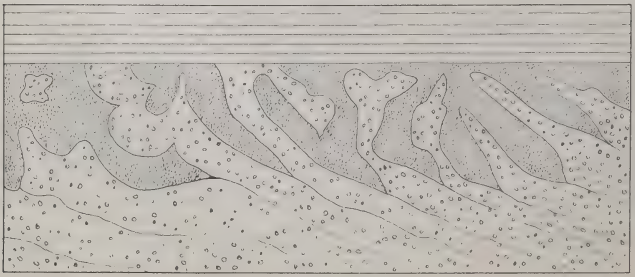


FIG. 4.



arriving at a correct theory of its accumulation. Since then a paper has been read at the Geological Society, by Mr. Trimmer, in which he attempts to explain them by supposing that masses of ice had been fixed amongst the beds when they were deposited, and that, on these subsequently thawing, the strata above sunk down into the space they occupied. Both these suppositions are undoubtedly true causes, and in some parts of the globe contorted stratification must now be produced by the action of both. My own opinion is that some of the contortions in the drift are due to one, and some to the other, and that neither alone is sufficient to account for all that occur.

Those to which I shall particularly call attention are in the neighbourhood of Bridlington; for the drift there, consisting to a great extent of horizontally stratified thin-bedded sand and clay, exhibits many facts which cannot be observed when, as is frequently the case, the boulder clay constitutes nearly the whole.

In the first place I will describe an example of what appears to me to require the explanation suggested by Mr. Trimmer. This is shown in *Fig.* 1, *Plate V.*, in which, as well as in all the others, those parts with round marks are boulder clay; those with dots, gravel; and the rest more or less fine sand: the line drawn below each being the scale of one yard. At the lower part is boulder clay, in which there appears to have been a kind of inverted funnel-shaped cavity, much broader at the bottom than at the top. This is now filled with gravel and sand, which is arranged in such a manner as to indicate that it entered through the opening at the top in a mass, and not as if deposited in it gradually. The beds just above are broken up, as though they had in part subsided into the supposed vacuity, but a little higher up they are horizontal and undisturbed. Such a case as this, I think, could be readily explained, by supposing that a mass of ice was lodged amongst the boulder clay, over which beds of gravel and sand were deposited, which, on the subsequent thawing of the ice, sunk into its place; horizontal beds of sand and clay being afterwards accumulated over the whole.

The contortions which occur in the fine-grained, thin-bedded, sandy clay are, on the whole, perhaps the most striking. The general character of those in it, as well as in other deposits, is that at the bottom are perfectly undisturbed beds, and over these, the junction being quite sudden and distinct, are others of precisely the same nature, but bent and twisted, in the most remarkable manner, into very complicated and intricate curves. The surface of the contorted beds has then been reduced to a level, the projecting parts removed, and other undisturbed horizontal ones accumulated over them.

We are hence compelled to admit that no disturbance from beneath could have given rise to the contortions, for in that case the beds below would have partaken in the movement. Neither could any acting since the accumulation of the upper beds, or else they could not have remained horizontal. These facts, and especially the connexion of the disturbed part with those on each side which are not so, will be best seen from the very limited case shown in *Fig*. 2. At the bottom is a mass of thin-bedded fine sand, quite undisturbed; but at the upper part, where of precisely the same nature, even ripple marks being traceable, the beds are bent up into great curves. As will be seen, the contorted beds pass on the left side into perfectly undisturbed ones, whilst, on the right, they end, more or less abruptly, in a mass of fine sand, showing little or no trace of stratification, but farther on becoming regularly bedded.

Now such a case as this, I think, proves most clearly that there has been some force applied on the right hand side, which broke up the beds and pushed them along into curves towards the left; and it appears to me that an iceberg is the only probable agent which could have done this. In this instance, the contorted portion extends only five or six yards, but it frequently is ten times that length, and then the curves are often very much more complicated. The upper part has been washed level, and a horizontal bed of gravel deposited over it; though fine-grained thin-bedded sand and clay are often found just above the contortions, and hence they cannot have been produced by any violence of current; though I have seen cases in confusedly bedded sandstone rocks which appeared to require that explanation.

But besides those contortions which seem to have resulted from the action of a lateral force, there are others which indicate one proceeding from above. In some parts, of limited extent, it is not uncommon to find the beds of gravel and sand full of small faults, such as shown in *Fig.* 3, and by tracing the beds laterally, I found that the disturbed portion was depressed below the general level. This fact, as well as the character of the faults themselves, leads to the inference that they resulted from a force acting, not from below, but from above. Another sort of case, indicating the same fact, is shown in *Fig.* 4. Here, at the bottom, is boulder clay, rudely stratified, and, as will be seen, the beds have been broken up along their partings, and gravel forced in amongst them. It is extremely improbable, not to say impossible, for these deposits to have been accumulated as they now are; but I think the supposition of the action of a force from above would explain the facts of the case. In this instance, also, it will be observed that the upper surface was reduced to a level, and horizontal undisturbed beds of fine sand and clay deposited.

I, therefore, contend that the contortions I have described indicate a lateral force, or one acting from above; and since there are so many other facts leading to the conclusion that icebergs were, to a great extent, instrumental in depositing the drift, I think that we must also refer these irregularities of stratification to their lateral movement or downward pressure at the fall of the tide, when left stranded. The directions in which the pushing force must be supposed to have acted also agree with this theory. Though there is evidence of much oscillation in the level of the land at the period of the drift, the character of the shells found in it at Bridlington indicates a depth of not more than 100 feet, and that dry land was near. This would lead to the inference that the chalk wolds were then above the sea, and, if so, there must have been a kind of bay at Bridlington, somewhat similar to the present. I have very carefully investigated the directions of the currents in this bay at the period of the drift, as shown by the ripple marks and other facts, and have been led to conclude that a tolerably strong current swept round its shores; and that, in the centre, it was more tranquil and had a returning eddy. Comparing the directions of the currents with those of the contortions, I find, almost invariably, that the side on which the pushing force acted in the different parts of the ancient bay, agrees with that which would result from the drifting of an iceberg in the line of the current which prevailed there.

Since, as I have above described, whenever the contortions are well displayed, they are seen to be underlaid and surmounted by undisturbed beds, the time when they were formed is absolutely fixed within narrow limits; and, since they occur throughout the whole period of the drift, from the earliest to the most recent, it is clear that they cannot have been of contemporaneous formation. Hence we are compelled to suppose that the cause, whatever it might be, which produced them, acted during the deposition of every part. If, therefore, it is requisite to consider them to be due to the action of icebergs, we are led to the rather important theoretical conclusion, that they were present during the whole drift period, and not, as has been supposed by some highly distinguished geologists, merely at its close.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FORTY-FOURTH MEETING, HELD IN THE PHILOSOPHICAL-HALL, HUDDERSFIELD, ON THURSDAY, APRIL 15TH, 1852.

The Rev. Josiah Bateman, Vicar of Huddersfield, in the Chair.

R. Dudley Baxter, Esq., of Doncaster;
H. W. Ripley, Esq., Holme House, Lightcliffe; and
Richard Solly, Esq., Field Head, Sheffield,

were proposed and elected Members of the Society.

The Chairman, after announcing the titles of the communications to be submitted to the meeting, called upon George Bodington, Esq., M.D., of Sutton Coldfield, to read the first paper—

ON A METHOD OF EVACUATING COAL MINES OF INFLAMMABLE GAS.

Dr. Bodington commenced by observing, that his only object in appearing before them was to endeavour, if possible, to render some service in ameliorating the condition of the miner, as far as his safety was concerned; and this he did without any practical knowledge of the working of coal pits; and if he failed in effecting any good, he trusted the attempt would be excused on the ground at least of good intentions on his part. He then proceeded as follows:—

The plan I have to recommend for your consideration, consists of an Arterial Ventilating Apparatus; that is, one resembling in some degree the arterial or venous system of the animal body, a natural mechanism for moving and circulating a fluid substance, the blood. Now, as regards this, one side of the instrument, the heart, effects the object by creating a vacuum by its action. When the right auricle or cavity of the heart empties itself, the blood immediately rushes in from the veins to fill up the vacuum; but this action of the blood operates upon the whole column in the veins down to the remotest capillaries. The whole of the blood is moved forwards and upwards to the extent of the quantity required to occupy the space described by the emptied auricle or cavity of the heart. This movement is aided by the presence of valves in the course of the veins, which act by preventing any retrograde movement of the blood.

The object I have in view is to apply the principle of this natural hydraulic machine, to pneumatics, or to operate upon gaseous substances in a similar simple way.

There may be difficulties in the way of its application to coal mines for the purpose of drawing off fire damp which I may not have foreseen, inasmuch as I have never been in a coal pit; and I am told there occur breaks or "fallings in," which would obstruct the application of the arterial tubes; I can only say that the system I speak about would not require an uniformity of level or of direct course, but might deviate in any serpentine form, without thereby being impaired in its efficiency: the pipes might be conveyed through the breaks or round them.

To effect a circulation of air through the arterial tubes, there must, at the outlet or evacuating pipe, be a system of exhaustion or rarefaction kept up, either by heat or by an exhausting air pump of large capacity, and worked by the steam engine or power of the mine. This would maintain the circulation of the air from the interior of the mine, and as fast as the foul air was withdrawn, fresh atmospheric air would descend down the shaft to supply its place; thus a constant circulation would be kept up. As more space was made in the mine by the removal of coal, more pipes would be constantly added, as branches to those already fixed. Thus the extension of the arterial ventilating apparatus would be equal with the advance of the works and the extension of the mine.

As a very prominent subject with the public just now, perhaps I may be permitted here to allude for a moment to the somewhat analogous question of the ventilation of the House of Commons. Much money appears to have been unnecessarily expended. It certainly appears to be simply a question of exhaustion or rarefaction of the atmosphere of the House. And that process would probably be more conveniently and effectually carried on in the upper regions of the room, and, as it were, out of sight, and on the simple principle which I have here suggested for the evacuation of the foul air of mines. It is evident the renewal of the atmosphere of the House, as in mines, must come spontaneously from the common atmosphere; and it might be warmed as it approaches by being brought into contact with pipes circulating hot water in the passages and lobbies. I had the presumption (it may be) to direct public attention to this subject in a letter which appeared in the *Morning Post*, of 24th February last; and I only mention it here from its analogy to the subject of this discourse.

I would remark, that there is probably yet much to be acquired that may be useful to man, by a more diligent study and observation of animal or natural mechanism, and adapting the principles of a perfect standard to the more imperfect science and artificial mechanical contrivances of man. To the weaver, a microscopical and minute investigation of the various membranes and tissues of animal structure, might possibly suggest some novel idea. The dyer might inquire, how does nature colour or dye her various fabrics? The architect may improve his principles by studying the pillars and supports of the human skeleton, and the skeletons of the lower animals. The most perfect arch is contrived in the human foot, and no artificial system of fortification can equal in perfection that of the spine and skull appertaining to animal life. The pullies, joints, and hinges of living structures, are inimitable in their construction. The hydraulic and pneumatic principles of animal life are destined yet, I trust, to teach us much which may be of the utmost importance to the interests of mankind.

It was from reflecting somewhat on these subjects that I took up the idea that ventilation generally might be rendered more perfect and effective, and that large cities and towns might be better, and with more facility, supplied with pure fresh water. I have got this very rough and imperfect instrument made by a common mechanic,* which combines, as it were, a pneumatic and hydraulic principle in conjunction, and which I intended for the purpose of showing how fluids may be easily lifted into any position, independently of their tendency to find their level under ordinary circumstances. Thus, by working this small exhausting syringe, and withdrawing the air from the first compartment of this zinc tube or pump, the water in which it stands in the basin immediately rises, to occupy the spaces vacated. And thus, by successively exhausting all the air of the several compartments into which this tube is divided by three or four valves, the water at length rises to the top, and by turning this stopcock, flows out.

Now if this tube was a mile long, or a hundred miles, or even encircled the globe, the whole of its contents, to the furthest extremity, would be moved forward by simply continuing a process of exhaustion at its commencement; and if the remote end of the tube was immersed in water, a continuous stream might be circulated and evacuated, provided the machinery, by clever mechanical contrivances, was rendered perfect. By this means, a river twenty miles from London might, by being dammed in its course, be readily elevated to the metropolis by means of the exhausting system; and being deposited in reservoirs on elevated ground, be dropped down into the city, to conduce to the health and comfort of the inhabitants.

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* Dr. Bodington exhibited the instrument alluded to, to the meeting.

It is the same principle precisely which I now recommend for trial, with the view of rendering secure the lives of those valuable men—the miners—who constitute, in reality, the foundation of the wealth and strength of society in this country. I say the same principle might be made applicable to gaseous substances. Then comes the question—Who is to carry it out, or undertake the experimental trials? If successful, who is to ensure its general application? Now, I think there ought to be no half measures on a subject of such extreme importance, and that a Government Commission ought to be appointed, with powers to carry out the objects in view. I cannot conceive the mere appointment of inspectors a sufficient step for the Government to take on a matter of such grave consequence to the nation. They are not armed with the necessary powers. The laws relating to pauperism or to lunacy are administered by Commissions, and yet I cannot deem them to possess a tithe of the interest that this mining question possesses. This relates to the existence or non-existence of the (strictly speaking) most valuable class of society; and it is most lamentable to hear so frequently of their being blown to atoms, or, indeed, to hear of their emigrating, on account of bad times, to add their strength and their wealth to the interests of foreign rival nations. I see by the newspapers that such is the case from the mining districts of Wales, and I deem it to be a great national loss and misfortune, and replete with future evils to this country. I cannot, then, think that I can be wrong in recommending a Government Commission on this subject, through the medium of which the whole state, condition, and position of the huge mining interests of this country would be constantly placed before the Government and the country.

But lacking that power, in the meantime, if there are any gentlemen who are willing to combine for the purpose of experimentalising, or attempting a practical trial of this scheme of mine, or of any other, I am sure I would be glad to co-operate with them, if I could bring the smallest suggestion to bear upon the subject usefully.

The Davy lamp, scientific and ingenious as it is, has one practical disadvantage, and that is, its dependence upon the men themselves for its constant application and use. Now, if possible, the remedy should be one acting in entire independence of the miners; for experience fully shows that the constant exposure to danger renders them indifferent to it, and that in this respect they are unfit to be entrusted with the safe keeping of their own lives.

Now, as money constitutes the sinews of war, we cannot contend with the evils in question without it. The community at large ought to find the means for ensuring the safety of the lives of the miners, to whom they are so largely indebted. A small tax upon coal at the pit's mouth would, of course, be a tax upon the whole community, who are the consumers, and it would be an equal and fair tax, inasmuch as wealth would pay it in the exact proportion to its amount or extent. The man who lives in a cottage would pay but little; the occupant of an extensive mansion would contribute largely, according to his wealth. Thus, I think, a moderate tax upon coals would fulfil all the great requirements of the first principles of taxation, which are, that all should contribute, but all in proportion to their means. Having raised funds, then, by these legitimate means, applicable to the objects we have in view, depend upon it, gentlemen, those objects would be attained, and that without in the slightest degree affecting the interests of the coal masters, or touching their pockets, beyond those of the rest of the community, but, on the contrary, greatly benefiting them by establishing order, regularity, and security in the mines and amongst the men employed in them. It may be that the coal masters would prefer to keep these matters in their own hands, rather than be interfered with; but is it not hopeless to expect unanimity? The remedy ought to be complete and universal,—if partial, it will not be satisfactory. It must be general and compulsory, and paid for by the public at large.

I certainly think it behoves the masters now to combine and subscribe towards establishing and proving the soundest, safest, and most practical principle as a remedy against inflammable gas in mines; and having done that, to memorialise the Government to appoint a Commission with full powers to carry it out to the widest extent. And there are many other evils and dangers to which the mining community are exposed, which such a Commission would sweep away.

P.S. If the principle of accelerating and effecting the circulation of fluids by a series of consequential vacua, in imitation of the natural forces employed in the circulation of blood in the venous system of animal life,—in physiological language termed *vis a tergo*, but which is, more properly speaking, the result rather of a preceding power, consisting of an alternate exhausting or suction force, and a propulsive or evacuating action, at the head of the column of fluid, rather than of any force from behind,—could be once fairly imitated artificially, and applied to the various purposes of life, then a solution of most important questions would be obtained; as, for instance, the evacuation of sewage through a horizontal or level, or even an ascending course, to convenient localities; the supply of pure water to large towns; the improvement of the common pump; and if applicable to gaseous substances, the ventilation of mines as above suggested.

ON THE OSCILLATION OF THE CURRENTS DRIFTING THE SANDSTONE BEDS OF THE SOUTH-EAST OF NORTHUMBERLAND, AND ON THEIR GENERAL DIRECTION IN THE COAL FIELD IN THE NEIGHBOURHOOD OF EDINBURGH. BY H. C. SORBY, ESQ., F.G.S., SHEFFIELD.

Those peculiarities of structure in sandstones, from which the direction and velocity of the currents which deposited them can be ascertained, have been so little attended to, and so imperfectly understood, that it will be desirable to explain their general nature, before entering upon their application to particular districts.

If water, holding sandy particles in suspension, deposit them when tranquil, or when moving only very slowly over the bottom, the resulting beds are level and horizontal; which structure I call "level bedded." If, however, the current move over the surface of the sand at the bottom with a certain moderate velocity, systems of waves are formed on it, trending, on an average, perpendicular to the line of the current, in the same manner as when a breeze blows over water. When, for a short interval, the velocity becomes less, these ripples become permanent, and thin layers may be deposited conformably over them, gradually becoming level. This process being repeated, a mass of rock may be formed, having a structure which I call "ripple laminated." By observing the direction of these ripple marks, the line in which the current moved may be known, though not the direction from which it came; but this can almost always be ascertained from the presence of the structures described below. If the current becomes somewhat more rapid, not only are ripples formed on the surface of the bottom, but the particles of sand are drifted forward, and thrown down in layers on that side of the ripples towards which the current moves. This structure is what I call "ripple drifted." When the current becomes more powerful, these waves increase in size, and pass into that structure which is generally called "false bedding," where the separate thin beds are inclined at an angle of about 30° to the plane of true bedding. This I call "drift bedded;" and in it, as well as the much smaller variety, which I name "ripple drifted," the direction from which the current came, is the opposite to that of the dip of the detached thin beds, in relation to the plane of true bedding.

When either of these structures is observed in progress in modern sand drifts, admirable examples of which, on a large scale, are to be seen at both ends of the Menai Strait, it will be perceived that the line of the dip of the talus is not constantly in the true direction of the current, on account of the formation of complicated deltoid deposits, in which the line of the dip of their sloping termination varies very considerably on each side of that of the current. Its mean direction, however, coincides with it; and, hence, if a number of properly placed observations be made, their mean gives a result very closely agreeing with the true line of the current.

From one or other of these structures, then, the direction of the current which drifted onwards a bed of sandstone can almost always be ascertained; and to illustrate the accuracy that can be attained, with proper precaution, I would mention that, in many cases, where I have observed it in quarries in the same bed of stone, at a short distance apart, the mean results do not differ more than a few degrees from one another; and, when they do, if the bed be examined further on, it is often seen that the difference obeys a particular law, and results from some gradual change in the direction taking place at that part, from the mutual interference of different currents, or otherwise. By attending, therefore, to these peculiarities of structure, the direction of the current can be ascertained with great precision, and also its comparative velocity, and I have no doubt, when my inquiries are completed, that its rate in miles per hour, will be determinable within certain limits.

I have found it of the greatest advantage to adopt certain symbols to express the structures I have described, so that I may not only state the direction of drifting of any particular bed, but also indicate the exact character of that structure by which its velocity may be known. These symbols are for—

Level bedded — Ripple drifted ∾
Ripple laminated ∽ Drift bedded ∠

I have chosen them with great care, so that they may represent, hieroglyphically, the character of the structures, be easily written, and also printed by types in common use, which are the single dash, and the mathematical sign for an angle, the section printed lengthwise, and the same with a portion cut away. By writing these down in the order in which the amount of each structure preponderates in a sandstone bed, and also signifying the direction of the current, most valuable information is afforded of its nature and origin. When making the researches included in this paper, I had not contrived this useful notation, and hence I am sorry to say that I cannot so fully describe the exact character of each bed as I could now; but I trust I shall be able to do so with sufficient accuracy for the objects in view on the present occasion. Presuming that my methods of research, and the terms and symbols I have adopted, will be sufficiently well understood, I will now briefly describe some of the general results derived from their application to particular districts; and I might here remark, that all the directions given in this memoir are referred to true north, due allowance having been made for magnetic variation.

The lower new red sandstone of the south-east of Northumberland is well seen in the coast-section at Tynemouth. South of the small cove the drifting is from N 15° E, and in the lower part, north of it, from N 9° E, whilst in the upper part, 40 or 50 feet above, it is from N 4° E. It will, therefore, be seen that the directions are very uniform and regular. The mean of the whole is N 9° E. This bed is seen again about a mile north, at Cullercoats, on the other side of the ninety fathoms fault, and there I found that the direction of the current was from N 20° E. Between Hartley and Seaton Sluice, about six miles north of Tynemouth, there is a small patch of sandstone, very similar in character to the lower new red, and quite distinct from any other found in the coal strata of the vicinity, and hence I think it is in all probability a portion of that bed. This was drifted from N 17° E; and it should, therefore, appear that, in a distance of six miles, nearly in the line of the current, its general direction was very uniform, there being only a difference of about 10° in the observed means at the various places; in all of which the structure indicated a current of considerable velocity, nearly the whole consisting of drifted beds.

To describe in detail all the beds of the coal strata, seen in the coast section, would be very tedious; I shall, therefore, confine myself to certain points of considerable interest, and give a list of some of the beds, with their characters and the directions of the currents which deposited them. Under the two-gun fort at Tynemouth, at the bottom of the cliff, there is a considerable bed of sandstone, ∠ from S 62° E, above which is a soft tranquil deposit, then a bed of coal, from two to three feet thick, over which is another tranquilly deposited bed of shaly clay, and above it another of sandstone, ∠ from N 32° W. In both these beds of sandstone, the drifting is so clearly marked, and so very many good examples can be observed, that there is no room for hesitation about the direction of the currents. It would, therefore, appear that, after the period of tranquillity, during which the fine deposits and coal were formed, the next current drifting sand was from a quarter almost the very opposite of that which accumulated the lower bed.

I will not take up space with describing the directions of drifting of some small beds, detached by faults or otherwise, but will now give, in ascending order, a list of the chief beds, with their general character, and directions of the currents, in sections where the beds are seen continuously for some considerable distance in extension and thickness. From Whitley, passing south to Cullercoats, we have

Sandstone ∠ — ∽ from N. 33° W.
Sandstone — ∠ from S. 3° E.
Sandstone ∠ from S. 62° W.
Sandstone ∠ from S. 13° E.

The thickness of these sandstones, drifted from various quarters, without any definite tranquil deposit separating them, must be from 50 to 100 feet.

Soft — bed.
Thin bed of stony shale ∽ from N. 40° W.
Soft — bed and coal.
Tolerably thick sandstone, bottom — ∠ from N. 16° W.
Middle ∠ from N. 5° W.
Top ∠ from N. 2° W.

This shows a tolerably uniform current during the whole period of its deposition, with a gradual change towards the North.

Soft — bed.
Thin sandstone, ∠ from N. 27° West.
Soft — beds.
Thin sandstone, from N, 25° W.
Soft — bed.
Thin sandstone, ∠ from S. 10° E.
Soft — beds.
Thick sandstone, ∠ from N.
Soft — bed.

Another very good continuous ascending section is seen from Curry Point North, towards Hartley.

Sandstone, ∠ from N. 47° W.
Soft — bed.
Sandy shale, ∽ from S. 52° E.
Soft — beds and Coal.
Thick bed of — sandy stone, with ∽ from N. 30° W,
Sandstone, ∽ from N. 78° W.
Soft — beds.
Sandstone, ∽ from N. 84° W.
Soft and harder — beds.
Sandstone, ∽ from S. 25° E.
Soft — beds.
Sandstone, ∽ from S. 25° E.
Soft — beds.
Sandstone, ∽ from W.
Soft and harder — beds, and coal.
Sandstone, ∽ from S.
Soft and harder — beds.
Sandstone, ∽ from S. 25° E.
Soft and harder — beds.

These beds then indicate very considerable changes in the directions of feeble currents.

There is then a very considerable fault, bringing up a thick bed of sandstone, which, at the bottom, is ∠ from N. 19° E., and passing upwards, it was seen to become gradually more and more East, until, at the top, it was ∠ from S. 81° E.

At Seaton Sluice is a thick mass of sandstone, which may probably be the same bed as that just described, though I am not quite certain. The lower part is ∠ from N 10° W., the central — ∠ ∽ from S. 6° E., the top ∠ from N. 86° E., and about half a mile further North the upper part is ∠ from S. 80° E. This, then, shews that there was a total change in the direction of the current during the deposition of the central part, which produced a more tranquil deposit, probably owing to interference; and then, at the top, there was a bed drifted from an intermediate quarter, very uniform for some distance. If this bed be the same as the one seen about a mile South, as before mentioned, it would appear that the upper and lower portions, in both, indicate a close agreement in the directions of the currents; but that in place of its gradually changing, an interference with some other current characterised the central portion of the bed at Seaton Sluice.

It would be tedious to refer to all the particular cases which have led me to form the following conclusions, but they may all be derived from an examination of the sections I have described, and some others of a similar nature. We have, in the coal strata of the coast-section, between Tynemouth and Seaton Sluice, beds drifted from very various quarters, but yet they may all be divided into two leading groups, viz., those which have come from some point between North-East, passing through North and West to South-West, and those from between South and East, there being none from any point between South and South-East, or East and North-East. These, in the sections, are not grouped with any definite regularity, first one and then another set predominating, with or without any intervening period of tranquillity, during which soft level-bedded strata could be accumulated. It may, therefore, perhaps, be concluded, on the whole, that this line of section cuts across a tract where there was an interference of general currents from somewhere about South-East and North-West, which, alternately existing alone, or mutually more or less interfering, gave rise to various other directions, and to some of those periods of tranquillity, when beds, indicating very feeble currents, were deposited.

I have applied a similar method of research to the coal field in the neighbourhood of Edinburgh. I had not time to trace the various beds on the surface, but measured the directions of the currents in the greater part of the accessible points within ten miles of that city, which are not very numerous, and in many quarries the stone is so regularly bedded that it could not be ascertained. It would be tedious to describe the facts seen in the various places, and I shall, therefore, give the resulting means in a tabular form :—

Bed of the river, near Deanbridge, N. 54° W.
Craigleith Quarry, N. 37° E.
Gilmerton Edge, N. 83° W.
Dalkeith, by the bridge, N. 21° W.
Dalkeith Quarries, a mile East, N. 3° E.
Dalkeith bed of N. Esk, N. 3° E.
Auchindinny Mill, S. 3° E.
Granton, N. 8° W.
Kirkaldy, N. 30° E.
Beds along the coast from Kirkaldy to Kinghorn............ N. 7° E. / S. 38° E. / N. 17° E.
Drummore, N. 30° E.
Tranent, N. 18° W.
Inveresk, N. 78° E.
Joppa, N. 27° E.
Portobello, N. 39° E.
Slateford, N. 2° E.
Straiton, N. 28° W.
Humbie, near Winchburgh, N. 37° E.
Cramond, N. 67° E.
Crichton, N. 21° W.
Gorebridge, N. 41° W.
Stobhill, N. 18° W.
Arthur's Seat, N. 38° W.
Roslin, N. 22° E.
Bonnyrig, N. 33° W.
Goukshill, N. 54° E.
Newbattle, N. 67° E.
Dalmahoy, S. 19° W.

Taking the average of all these local means, the general direction is N. 4° E.

Comparing them together, it will be found that, not only does the general mean indicate a drifting from near North, but the number of cases, included between North-East and North-West, is five times as many as in an equal portion of any other part of the compass, and those North of East and West are nine times as numerous as those South. We may, therefore, conclude that the general direction of the drifting in the coal field about Edinburgh is mainly from North-East to North-West, only slightly interfered with by a southern drift.

I have examined the arrangement of these means, with a view to ascertain whether any definite connexion could be traced between their direction and position on the map, and, although I have detected some kind of a law, yet I forbear to describe it, not having explored sufficiently wide a tract to test its accuracy. My chief object on the present occasion is to show what may be made out by carefully studying the drift structure of sandstones, and I shall not further enter into the subject at present; for, being occupied in tracing the beds, and ascertaining the directions of the currents, over a space of about sixty square miles, in the neighbourhood of Sheffield, I have ascertained several facts of considerable importance in the theory of the formation of the coal strata. When these researches are concluded, I shall probably lay them before this society, together with an outline of such general conclusions as they appear to indicate.

ON CERTAIN CAVITIES IN THE LIMESTONE DISTRICT OF CRAVEN. BY MR. THEODORE WEST.

Having lately been on a Geological ramble in the neighbourhood of Skipton, my attention was particularly drawn to certain cavities or hollows in that part of the district known as Appletreewick Moor. These hollows run in a pretty direct line East to West, along or very near the edges of the limestone beds; in fact, just where the limestone is disturbed or replaced by strata of grit and shale. They extend at irregular intervals for a distance of several miles. In form they are mostly circular, and it is this marked regularity of shape, along with other circumstances, that impresses one with the conviction that some special cause must have produced them, and not any chance or purely local disturbance. As to number, there are upwards of two hundred; at least so I was informed by an intelligent man whom I engaged as guide, and who, living in those parts, knows them well. They are in the form of an inverted cone, and vary in size; one of the largest, which I measured, was about fifteen yards (45 feet) across, at the top, and about the same depth. With this brief description (which, however, includes about all that can be said of them,) it becomes an interesting inquiry as to how they have been produced. The first and most natural supposition is that they are artificial. Against this it may be said there is the absence of all reasonable motive for any such excavations. They are in a wild part of the country, in the middle of a large tract of moorland, which has been for centuries only a cover for the plover and moor fowl; and various tokens, visible on the spot, but which can hardly be described, seem to forbid such a supposition. As one, however, we may point to the large grit boulders which are found in many of the holes, occupying various positions such as they hardly could have done by other than natural means. There is abundant evidence that, at some remote period, the whole of this tract was subject to remarkable changes, of which only slight indications now remain. Thus we find profusely scattered, in the most picturesque confusion, huge boulders of waterworn gritstone, lying on the top of the limestone, which must by some whelming force have traversed miles of country until left to settle in their present position. The presence of these in many of the holes now described, clearly shows that both appearances are of somewhat ancient date. Had these been produced by artificial means, too, we should in all probability have found some trace of what had been dug out. Some have supposed that water has been the agent, and that these cavities were made in what once formed the bed of some majestic river or torrent. These boulders, hurried round in the whirl of the water, are thought to be the standing proofs of the process having taken place. If so, we should probably find traces of the action of water, if not at least one such pebble in each cavity. No such traces are now visible. Others, again, contend for volcanic agency, and that when the mass of limestone was in a fluid or a plastic state, a jet of gas must have forced its way through, and that these are consequently the mouths of so many extinct volcanoes. So far as could be ascertained, however, by digging down into several until we came to the solid rock, no such means has been at work; at least no trace of fire is visible on the texture of the stone; and had they been caused by any such force from beneath, whether a jet of steam or gas, some traces, either in the shape of lines or grooves in the sides, or of masses of ejected refuse lying round, would surely be visible.

But one supposition, then, seems left; and this, perhaps, the most likely of all:—that owing to the roof of certain natural hollows at some depth in the earth having fallen in, the ground above has gradually settled down to fill up the void. The shape, and the entire absence of mounds of refuse—for it is quite flat all round—seem to confirm this. This, however, it will be seen, only gets rid of one set of hollows by substituting another, by no means a particularly philosophical mode of explaining away a difficulty. One other rather singular formation drew my attention, as somewhat connected with these holes, or at least very near them.

On a part of the moor high and dry, and far removed from any water, we observed a slit or opening in the heather, about a foot or two across, and two or three yards long. On tearing away the heather and superincumbent soil, the curious appearance of the limestone at once caught our attention. The specimen which I have the pleasure to present to you will explain this better than any description.* Whether these furrows have been produced entirely by the action of water, and if so, during what time,—whether to count by years, by centuries, or by ages,—whether it has taken place altogether in their present position, and if so, how the water came there,—and why the action was circumscribed within such narrow limits,—are all questions more easily put than answered. It seems most likely that the water must have been greatly assisted in this action, by its having absorbed a large quantity of carbonic acid; and I was interested to learn, on making some inquiry of the lead miners who live thereabouts, that at certain seasons of the year, or during particular changes of weather, a strong current of air or gas issues from some such holes; in certain instances evidently carbonic acid, as they found, on approaching the jet with a lighted candle, it was instantly extinguished, or, as was expressed by them, went black out.

Frequently in winter, the snow, though very deep all round, is almost suddenly melted on the spot immediately above these holes, by this current of vapour from below; and, as a further proof that hollows, both such as this last described and the former ones, communicate with others of considerable size underground, I learnt that in heavy falls of rain, or at the breaking up of winter, when the hill streams come down in torrents, the water will, every now and then, find its way into some of these holes, where, instead of, as one would naturally suppose, its filling them up and forming pools (at least so long as the flood lasted), the water runs away into the earth as fast as it can pour in on all sides.

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* A specimen of the stone was here shown, singularly furrowed in every direction.

On different shelves of the larger masses of fretted work, and at the bottom of the cavity from which we got out this specimen, were a number of smaller pieces, which might be called stalagmites, and which appear vitrified, so completely are they coated over with the deposited limestone. In some, the process is only partially carried out. It is a point by no means uninteresting to the Chemical Geologist, to observe or ascertain, in so narrow a space, that the water has had to fall or trickle through the exact point at which the water surcharged with carbonic acid ceased to dissolve and begun to deposit the solid matter.

ON THE DILUVIAL AND GRAVEL BEDS OF YORKSHIRE AND NOTTINGHAMSHIRE. BY THE REV. W. THORP, OF MISSON VICARAGE, BAWTRY.

The study of transported detritus is now exciting the attention it deserves, as a method of explaining some of the last changes which have taken place on the earth's surface. Capt. Portlock (President of the Dublin Geological Society) says, "In every sand hillock or elevated gravel bank, there is a subject of study, leading to the inquiry how such deposits have been formed; whether with a steady or slow action of the sea at higher levels; by the force of submarine currents; or any other form of glacial or aqueous agency.

In Yorkshire and Nottinghamshire there are at least *three* distinct extensive tracts of gravel, of different geological ages, and derived from different transporting currents. There are also some very extensive tracts of surface over which no traces of general gravel beds, or of general transporting currents, can be found; and these latter, (where no gravel beds are found,) require some investigation from the Geologist as to the cause of the absence of transported material.

I shall, therefore, shortly describe the three extensive tracts of gravel which cover great parts of Yorkshire and Nottinghamshire, and then offer some explanation of the absence of these deposits in the Yorkshire and Derbyshire Coal Fields.

Commencing with the north parts of Yorkshire is one of the largest and best known dispersions of boulders and gravel which Great Britain presents. These fragments, which consist of rocks now existing "*in situ*," in Cumberland, are dispersed, *first* on the west side of the chain of hills which separate Yorkshire from Lancashire as far south as the river Severn, *i.e.* by Castle Eden, Preston, Lancaster, Manchester, the valley of the Trent, over the plains of Cheshire, Staffordshire, and through and over extensive districts in Wales; but here there are certain exempted localities, which afford some clue to the causes which have likewise exempted certain places in Yorkshire, Derbyshire, and Nottinghamshire, from this deposit; and it is remarkable that no incursion of these boulders has been made over the chain of hills to the east, but the Penine chain has acted as a natural dam against them.

On the east side of the Penine chain, the Cumberland boulders cover the plain of York from the Tees to the Humber. Then, again, masses of granite from Shap Fells, (recognised even in hand specimens by any Geologist who has once seen this rock,) have passed over Stainmoor Forest, 1,400 feet above the sea, thence over the Oolite hills, 1,500 feet, down to the East coast, where the united thickness of the upper and lower beds of erratics is between 300 and 400 feet.

The boulder clay is from ten to eighty feet thick, but never exceeding this last thickness. Again, this same gravel extends across the Humber, on the sea coast of Norfolk and Suffolk, to the mouth of the Thames, at Margate.

When examined carefully, this diluvium consists of an upper and lower deposit. The *lower* consists of clay, with boulders scratched underneath on their longer axes. The *upper*, of fragments rarely scratched, and having much false-bedding, indicating rapid currents, and carried by water of no great depth. *Marine shells*, when found, are in a broken state, and lie above the beds which contain the bones of Mammalia, and the limestone pebbles are in no case perforated by boring lithodomi.

The Geological date of the Cumberland drift is ascertained as follows:—At Cromer, in Norfolk, this drift reposes upon a subterranean forest of trees. It also covers up the remains of mammalia, as at Kirkdale, &c.; hence this transport was made over pre-existing dry land, upon which plants were growing and animals dwelling. Again, there are large accumulations of this drift in valleys, proving the latter were excavated previously to its deposition. The scratching in the lower boulders upon the longer axes, and their accompanying clay deposit, is ascribed to the rubbing action of icebergs, or of glaciers upon the parent rock; while the absence of these marks in the upper beds, together with their irregular and mixed up stratification, indicate the deposit being accumulated under violent aqueous action in shallow water.

The conclusions respecting the Cumberland drift arrived at by Cumming, Trimmer, &c., who have studied its phenomena under all its phases, are—

1st. At the commencement of the period of the boulder clay formation, the relative level of the sea and land in the British Isles was not greatly different from what it is now.

2nd. That a great current, originating, probably, in the union of a North Polar current, with a modification of the present Gulf-stream, was constantly setting in upon the northern and western shores of Great Britain and Ireland, with the climate of an Arctic character.

3rd. That a gradual *submergence* of the area of the British Isles took place to the extent, in some parts, of at least 1,600 feet;—and subsequently a gradual *emergence* of the same extent.

The *submergence* is chronicled by the scratched rocks, and boulders of the true boulder clay series.

The *emergence* is marked by more elevated terraces or extended platforms of *rolled* boulders and gravel, sometimes being merely a re-distribution of the materials of the boulder-clay; sometimes the pebbles of adjacent rocks regularly stratified.

4th. That during the uprising, the severe and rigorous conditions of the climate were modified; erratics from more distant localities were dropped by the grounding and melting of ice-bergs; while the scratching and grooving action of littoral ice in a great measure ceased. The marks of uprising on the east and west coasts of Great Britain and the Isle of Man, are the last traces of the physical condition of the country during the glacial epoch.

Other subsequent *minor changes* have occurred:—the erosion by the sea, in the separation between the British Isles and the continent of Europe—a slight depression, to a certain extent, about fifteen to twenty feet below the present high water level, as indicated by water-worn caves and inland cliffs. Lastly, a slight subsequent elevation, in some situations, which has left a low line of beach above the present sea level, to the base of the pleistocene cliffs, inland, forming rich alluvial tracts on what were formerly the sands of wide estuaries.

The second range of diluvium to be described is a long narrow tract of gravel, which touches the northern drift before described, near the river Humber, extending down the rivers Aire and Calder, from Leeds, by Ferrybridge, to Goole, and about one to two miles in breadth. The pebbles are derived from totally different rocks to the last described, and are composed nearly altogether of the sandstones of the coal district of Yorkshire, intermixed with occasional fragments from the mountain limestone district of Craven. This gravel does not extend much north or south of the valleys of the Aire and Calder. Leeds stands upon it, and beds of it are found on the higher grounds near Rothwell Haigh, Oulton, &c.; and passing through the magnesian limestone at Ferrybridge, it is much mixed with the detritus of this rock. Pebbles of gannister or galliard, with fossil stigmaria, also the mountain limestone, as well as the character of sandstones, all belonging to the coal district, fully attest the direction of the currents, which, from west to east, have transported the materials of which this tract of gravel is composed. Its age and origin I will examine subsequently.

A little further southwards, and down the course of the river Don, another similar east and west range of gravel is found, extending from Doncaster eastwards, by Armthorp, Sandal, Thorne, to the south banks of the Humber. This tract is about two miles broad, extending over the back of the limestone, southwards, to Loversall, and changing the agricultural character of the soil. The pebbles of this tract of gravel are, in like manner, derived chiefly from the harder sandstones of the coal district, especially from the salmon-coloured rocks near Rotherham, together with others from the mountain limestone of Derbyshire.

The next tract of diluvium is the one more peculiar to Nottinghamshire, of which the first trace is seen, perhaps, on the Hambleton Hills, near Selby; and from this locality it is probable that it is covered by the more recent gravel. Then, again, from Doncaster southwards, through Nottinghamshire, up to the town of Nottingham, this gravel extends uninterruptedly on the back of the new red sandstone, being spread uniformly on the surface from three to eight feet thick; but on very abrupt hill sides, where the new red sandstone rock is hard, scarcely any gravel is present. Fragments of it are occasionally found lying on the magnesian limestone and upper red marl of Notts. South of Nottingham and Derby it becomes intermingled with the Northern drift before described.

The Nottinghamshire gravel is composed of fragments of rocks, of which no Geologist can assign the locality of the original rock. There are no pebbles of granite, sienite, or porphyry, or even mountain limestone. In speaking of the gravel beds of the forest of Notts, Farey says, "In all my examinations of this immense mass of gravel, except on the very surface, I did not perceive a single pebble which belonged to the neighbouring strata, or to any strata which I have seen in England. The fragments consist nearly altogether of quartz, sometimes veined, sometimes with square crystals embedded. The colours of the pebbles vary, and externally some of them appear like sandstone, but when broken exhibit no aggregation of particles, but are composed of pure quartz. Besides, these fragments are smaller, more even in size, and more spherical than either the boulders of the northern drift, or of the two tracts of sandstone described.

The Notts gravel has evidently been derived from primary igneous rocks, and that by currents which have drifted in a north and south direction. It is also more ancient than the two sandstone groups before described, since at Gringley, Everton, and at Newington, some gravel beds of magnesian limestone, evidently contemporaneous with two tracts of sandstone before described, lie on the top of it. Of these three isolated patches, I shall only remark, that they have been transported by currents out of the Yorkshire and Derbyshire coal fields, and are derived from the magnesian limestone near Maltby, where an extensive denudation in the limestone terrace exhibits the devastation made.

The materials of which the new red sandstone itself is composed, afford some clue to the origin of the Notts gravel, the bottom portion of which is in many places so perfect a conglomerate, containing pebbles of exactly the same size, that at first I was almost led to the conclusion that the gravel of Notts was nothing more or less than pebbles washed out of the subjacent new red sandstone. After repeated examinations of a large district, I found this position could not be maintained, and therefore the identity of the pebbles in the new red sandstone itself, the great similarity in size and absence of anything like large boulders, and the regular distribution, except in certain valleys, all prove their origin from ordinary marine action; in fact, that they constitute the ancient sea bottom left by the waters which deposited the new red sandstone itself.

To make my catalogue of the ranges of diluvium complete, must be named that by Everton Hills, near Bawtry, which extends up to Gringley-on-the-Hill, capping one of the highest points in Notts. This gravel is composed of magnesian limestone pebbles, to the exclusion of the coal measure sandstone rocks, and this differs from that of the Don and Calder tracts of gravel. There is no doubt of this, since pebbles of large size can be traced westwards up to Maltby, as before mentioned. The absence of sandstone pebbles is only accounted for by the abrupt terrace of coal measure rocks east of Rotherham. Here, suddenly, behind Rotherham, whence a long valley extends up to Sheffield, arises a sudden precipitous range of hills up to Wickersley, Ullay, and

Laughton, &c., eastward of which no detritus could readily have been drifted; hence only magnesian limestone detritus is found to be carried eastward over certain parts of Notts.

This magnesian limestone gravel, as I said before, reposes upon the old sea gravel peculiar to Notts, and therefore the latter is older.

Now leaving the origin, &c., of the northern drift, as explained by Trimmer and Cumming, I have to account for the three or four east and west lines of gravel, as well as the absence of the northern drift from the Yorkshire and Derbyshire coal fields, and from certain parts of Notts.

Taking for granted that the greatest part of Great Britain has been submerged, some parts to the extent of 1,600 feet, we cannot exempt the Midland Counties of Yorkshire, Derbyshire, and Nottinghamshire. But why is there no incursion of Cumberland boulders into this district, since southwards, up to the Severn, and into North Wales, on one side of the Penine chain, and again through Norfolk up to the Thames, on the eastern side, the whole surface is covered with this diluvium? Now it has been proved by Trimmer that in Wales, whenever a high bluff-land or range of hills presents itself to the north, to the south of such range the northern drift has not reached. The Snowdonian chain of hills has effectually protected Cardigan Bay (Crieccieth). Harlech Castle, as well as the high lands in Anglesea, have protected the Menai Straits. Also the Penine chain of hills, which separates Lancashire and Yorkshire, although ranging north and south, has never been crossed by this diluvium; and, therefore, I conclude, in like manner, the elevated millstone grit ranges in the north of Yorkshire, as around Wharfdale, Swaledale, and Airedale, between Brough and Harrogate, have protected and acted as a dam to any irruption from the north; and hence the absence of such detritus in the Yorkshire and Derbyshire coal fields, and of the great part of Notts.

Then, again, respecting the three or four ranges of east and west gravel derived from rocks now *in situ*, within fifteen to thirty miles of the drifted material, there can be no doubt that they have been exported from within the Yorkshire coal field, by the waters which were driven eastward during the time of *emergence* (mentioned by Trimmer), and down the lines of valleys which then formed the easiest retreat for the retiring waters. It is true that from organic remains in these counties, we have few proofs of submergence; yet one good one is worth a hundred in such a case, and there are now in Lady Milton's possession two shells found in the gravel of Notts, near Osberton, about sixty feet above the sea, which have been identified by Professor Edward Forbes as species of those now living in the German Ocean; and my friend, Mr. Denny, is now exhuming, from a brick field in the neighbourhood of Leeds, the remains of one or two specimens of the great northern hippopotamus.

Hence it is evident that there exist over this tract of country various deposits of gravel derived from very different sources,—each, however, significant of its origin; while there are also localities containing scarcely a single pebble, whose plains have been protected by the high bluff lands of the North of Yorkshire.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE ANNUAL MEETING, HELD IN THE PHILOSOPHICAL HALL, LEEDS, ON WEDNESDAY, DEC. 15TH, 1852.

JOHN HOPE SHAW, Esq., Mayor of Leeds, in the Chair.

His WORSHIP opened the business of the meeting by observing, that he was very sensible of the honour of being placed in the chair, but not so self-deluded as to mistake the grounds on which alone the Society would be justified in conferring such an honour, or he in accepting it. It could not be from any expectation of assistance from him in their scientific pursuits, his knowledge of which was only that general acquaintance with principles common to men of liberal education; enough to enable him to relish scientific discussion by others, but not to take a part in it. He could only have been selected for the chair on account of his public office in the borough, and of his having been formerly the President of the Society in whose hall they were assembled, and being still one of its vice-presidents, and a member of its Council. He then proceeded to remark on the high place of Geology amongst physical sciences, as second only to astronomy;—not, indeed, comparable with it in sublimity, (for the highest sublimities of earth sink into insignificance in comparison with the magnificence of that universe in which the earth itself was but a speck), but still presenting to us a series of wonders that must strike the mind with profound admiration.

It unfolded to us the process by which the present structure of the earth was formed; the order of its strata; the alternate elevation and depression of land and sea; the causes which had moulded its surface into the various forms it now presents to us; the tremendous convulsions which (at least when they happened suddenly) must have been fatal to animal and vegetable life, but which experience has shown to be blessings to us, since it was by their means that our vast mineral treasures were brought within our reach; and it exhibited to us, preserved as fossils, the framework of the bodies of the enormous creatures which inhabited the earth, and doubtless enjoyed their habitation, before it was fitted for man; and the prints of their footsteps on the primeval sand. But this Society aimed at applying science to uses more directly practical; and addressing, as he was then doing, an audience composed partly of visiters, unacquainted, or imperfectly acquainted, with the precise objects and operations of the Society, (as he himself was till he read its reports within the last two days), he did not think he could do any thing better than state the impression which the perusal of those reports had made upon his mind. He found that the Society had three main objects. The first was to ascertain Geological facts connected with our own district. Every one must admit that facts are the only sound foundation of physical science; but this, which is almost a truism with regard to physical science in general, has a peculiar significance with regard to Geology. In other physical sciences, when we have, by a sufficiently large induction, ascertained the existence of a general cause, we may, to a considerable extent, reason safely from cause to effect. Not so in Geology. There the regular operation of well-ascertained general causes was liable to so many interruptions from disturbing causes which were irregular in their operation, that the only safeguard against serious, and sometimes ruinous, mistakes, was to recur again and again, at every step, to the test of actual experiment, and to make our information (as the prospectus of the Society recommends) "minute and local." The second object of the Society was Polytechnic; or, in other words, the application of the means provided by art to the resources provided by nature, so as best to mould them to the uses and support of the great human family. To this head, one of the papers announced for that evening, on "The Iron Manufacture," would be devoted. The Society's third object was to ameliorate the moral and social condition of that large, and in a great degree isolated, class, who spend their lives in raising, or fitting for their appointed uses, the mineral products of our country. The mode in which the Society had prosecuted these objects appeared from the series of their papers, several of which he had had the pleasure and advantage of reading; and which, he thought, no one who had any taste for such studies, could read without admiration of the acuteness, research, and enlightened benevolence of the writers. There were papers on fossil remains; on our great mineral products, especially the two chief mineral products of our district, Coal and Iron; on the modes of working or using them to advantage, such as they would have that evening on the Iron Manufacture; on some of their principal applications in recent times, such as locomotives and their various improvements; on the different qualities of soil in different Geological Districts, on which class of subjects he was glad to see that Society in amicable intercourse with another important body, the Yorkshire Agricultural Association; on the qualities of water, a subject of great interest at all times, and at present of peculiar interest in Leeds; and, so far as regarded the workman, on improvements in his great protector from fire-damp, the Davy Safety Lamp, and on what, if thoroughly accomplished, might prove a still better protector to him, the ventilation of mines. These papers, the productions of writers who brought to their subjects extensive practical experience as well as theoretical knowledge, followed by free but courteous discussions and the friendly interchange of opinion, in a meeting of men who combined science with practice, could not but be productive of great good. But much as had been done, there was still much remaining to be accomplished, before the vast treasures of mineral wealth, which a gracious Providence had placed under their feet, had answered all the purposes for which His wisdom and benevolence designed them. There were districts to be explored; maps to be formed; statistics to be collected; improvements to be suggested; and information to be widely diffused, in order to secure the full benefit of these treasures. In our own district, those treasures were now blessing many hundreds with opulence, and many thousands with the means of happy subsistence; but the continuance and extension of those blessings depended on the active and judicious use of the means to which they owed their origin. To cultivate such resources with success, united and systematic efforts were indispensable; and it was the province of that Society to unite and systematize, and by that union and that system, to promote and assist those efforts. Such a Society was well entitled to the support of all who were interested (and who is not?) in the welfare of the community to which they belonged. Whatever apathy might have appeared (and in this neighbourhood there was unfortunately but too much reason to regret such apathy) with regard to the Society, must, he was sure, arise from its objects and proceedings not being sufficiently known. In his own case it was unquestionably so; for he had been very imperfectly aware of the extent or nature of the Society's labours till he read their Reports preparatory to taking the chair that evening; and the pleasure with which he had read them was not entirely unmixed with self-reproach, that such an institution had been labouring so many years in the town where he lived, without his having sooner manifested his sense of its usefulness. This omission he hoped they would allow him to repair to-night by becoming a member; and he had no doubt that many of his townsmen, if they could be induced to read the Reports, as he had done, would gladly and eagerly do likewise.

The Treasurer produced the following statement of the Receipts and Disbursements of the Society for the past year.

DR.	£.	s.	d.	CR.	£.	s.	d.
To Balance in Treasurer's hands..	11	17	8½	By Printing Reports	10	0	0
,, ,, Mr. Batman's hands.	10	18	6	,, Advertising Meetings..........	1	11	0
To Subscriptions from—				,, Lithographing Plates..........	2	11	6
,, 1 Member for 1846, at 13s.	0	13	0	,, Rent of Exchange Rooms, Bradford	1	1	0
,, 1 ,, 1847 ,, ...	0	13	0	,, Expenses of Meetings	2	2	6
,, 2 Members for 1848 ,, ...	1	6	0	,, Collecting Subscriptions	3	1	2
,, 4 ,, 1849 ,, ...	2	12	0	,, Postage Stamps	0	8	1
,, 6 ,, 1850 ,, ...	3	18	0	,, Subscription to the Palæontographic Society	1	1	0
,, 35 ,, 1851 ,, ...	22	15	0	,, Rent of Museum Room	20	0	0
,, 80 ,, 1852 ,, ...	52	0	0	,, Salary of Assistant Secretary..	50	0	0
Cash for copies of papers printed	1	19	0	,, Sundry Expenses	2	0	6
				,, Balance in Mr. Batman's hands.	10	18	6
				,, Balance in Treasurer's hands..	3	16	11½
	£108	12	2½		£108	12	2½
Liabilities........£29 15 0				Assets..........£28 12 0			

The Chairman then called upon Mr. Solly to read—

EXTRACTS FROM MISCELLANEOUS OBSERVATIONS ON THE MANUFACTURE OF IRON, AND ESPECIALLY ON CERTAIN QUALITIES AND PROPERTIES OF MALLEABLE IRON. BY RICHARD SOLLY, OF THE LEABROOK IRON WORKS, STAFFORDSHIRE, AND OF SHEFFIELD.

I was induced to offer this slight paper, from frequent experience that many persons, even of extensive general information, and of high attainments in special scientific pursuits, are not aware of the great variety which exists in the properties of malleable iron, and which render one kind of iron the most suitable for one purpose, another kind for another purpose.

The properties of iron are found in Great Britain to vary,—

1st. According to numerous conditions of the manufacture of the pig or cast metal, among which are—the kind of ore used, the flux, the fuel, the forms of the furnaces, the heat of the blast, the heat and degree of moisture of the atmosphere, and perhaps certain electrical and magnetic conditions which are not ascertained, but only suspected.

2nd. According to the process adopted in the manufacture of pig iron into malleable iron.

With respect to the ores, the varieties known in Great Britain are so numerous, that a mere geological and mineralogical catalogue of them would occupy far more time than could be allowed to an entire paper. To those members who have not yet examined the large official descriptive catalogue of the Great Exhibition, I would remark that in Class I., No. 427, they will find what I believe to be the most complete account of the iron making resources of this kingdom, as regards the ores. It is written from personal observation by my friend S. H. Blackwell, Esq., of Dudley; and his collection of ores was deemed worthy of a Council Medal. To him I am indebted for many of the following particulars.

The principal workable ores of Great Britain may be divided into three classes.

1st. The carbonates of the coal measures.

2nd. The hæmatites, or red oxides, of the carboniferous or mountain limestone formations, and also of the older rocks.

3rd. The carbonates and brown hydrates of the oolites.

The first class is subdivided into argillaceous and carbonaceous iron stones. The argillaceous iron stones are extremely varied in character, and in the per centage of iron they contain; they generally make a good quality of iron, possessing neither cold shortness nor red shortness in excess. They contain from 20 to 35, and in some cases even 40 per cent. of iron. The carbonaceous iron stones or blackbands, as they are termed, are most largely developed in Scotland and North Staffordshire, although also found in North Wales, South Wales locally, in South Staffordshire, and elsewhere. They contain, when raw, from 20 to 38 per cent. of iron; and when calcined they sometimes reach as high as from 60 to 65 per cent. They contain a large proportion of carbonaceous matter, varying from 6 to 25 per cent. This class of ironstone produces a cold short, but extremely fluid iron, most probably from the phosphoric acid which generally enters into their composition.

The hæmatites, or red oxides, are also sub-divided into two principal classes.

1st. The comparatively pure oxides of the Ulverstone and Whitehaven districts.

2nd. The calcareous ironstones of the Forest of Dean.

Both these varieties are remarkable for the red short tendency of the iron they produce; but which, nevertheless, stands high, from its great strength and from its peculiar fitness for tin plates, &c. The hæmatites of Ulverstone and Whitehaven contain from 55 to 68 per cent. of iron, those of the Forest of Dean from 35 to 50 per cent.

Besides these two great classes, there are also the brown hæmatites of Alston Moor and Durham, corresponding in some degree to those of Belgium and the hæmatites of the older rocks of Devon, Cornwall, and West Somerset. The first of these contain from 30 to 45 per cent. of iron, and make a fluid, and comparatively cold, short iron. The second are never used, except as a mixture with other ores, and rarely contain more than from 45 to 50 per cent. of iron.

The ironstones of the oolites, as at present known, may be sub-divided into—

1st. Those of the Middlesborough and Yorkshire fields.

2nd. Those of the Midland Districts.

The first, containing from 30 to 33 per cent. of iron, of a cold short character, but admirably adapted for foundry purposes, from the sound character of the castings which they make.

The second vary very much in character, and in the per centage of iron which they contain, varying from 20 to 55 per cent. They generally contain but a small proportion of alumina. The proportion of silica varies very much; sometimes rising as high as 40 to 50 per cent., while some varieties contain only 2 or 3 per cent. Carbonate of lime is occasionally largely present. These ores are said, by those who have most largely tested them, to produce iron of fair quality; but as they are only recently beginning to be used, some time will elapse before they are thoroughly understood. From the large beds in which they occur, sometimes 12 to 25 feet thick, they must ultimately exercise considerable influence on the iron trade.

The other known classes of ore are not of sufficient importance to require any enumeration here.

Although bar iron is very commonly divided by persons unacquainted with its varieties into two great classes, namely, good iron and bad iron, yet these terms can only be correctly interpreted to mean that a certain iron is suitable or unsuitable for the purpose to which it is applied; for I am not aware that there is any iron manufactured to be equally suitable for all purposes, nor that there is any so worthless as to be suitable for none. Some iron may be tough and able to bear great longitudinal strain; such iron is particularly fit for chains and chain cables, but *unless* it will weld easily without requiring such a heat as to injure the tenacity, the links will be liable to break where the welding exists. Other iron may be strong to resist impact, or sharp blows, and stiff,—such would make good axletrees; but unless it will turn well, free from asperities and black specks, termed greys, it is not approved. These greys are in reality very minute cavities; their perfect absence it is very difficult to attain; when attained, the iron is termed perfectly clear, and fetches a high price. If hard, it will be in request for all articles where a high polish, combined with stiffness and strength, is required; if soft, for objects requiring tenacity. Iron, soft and extremely tenacious, by which I mean that which will bear much bending backwards and forwards, and a great strain, without breaking, is also much esteemed for peculiar purposes, such as for the harpoons used in the capture of whales. Independent of the quality of the iron after it has been fabricated into the article to be used, it is highly important that it should bear the fabrication into such article with as little liability as possible to be spoiled in the process. A smith will say that such and such iron is *cold short*, or *red short*, or that it is *unsound*, or that it will not *weld*, or that it will not *punch*, or that it is *full of dirt*, or that, if drawn to a point, it becomes *brittle*. I will explain a little further some of these defects. When a smith puts a piece of bar iron into his smithy fire, he frequently heats it to a white heat, and then begins fashioning the article he is making; as he continues hammering, punching, and bending the iron, it assumes by degrees a yellow, and then a red heat. If the iron be red short, the moment it turns red, if the smith attempt to punch or bend it, the iron cracks, and his work is spoiled. Therefore, in working red short iron he is obliged to watch the colour carefully, and to suspend his work before it turns red, and to put it into the fire to re-heat it. This occasions a loss of time and greater consumption of fuel, and consequently increases the expense of manufacture. The usual mode of trying whether iron be red short, is by what is called the ram's head. If this can be done at one heat, that is, without replacing the bar in the fire, it is concluded that it is not red short. Cold short iron usually works well at all heats, and is not liable to crack when under the smith's operations, but when cold it will not bend far without snapping short with a granular appearance, the grain or crystals being much larger than in some of the best descriptions of iron, which *may* be granular, but the grains are fine and the colour silvery. Good common irons, and those of best quality for any but special purposes, when nicked on one side, and broken by the successive blows of a hammer, draw out and exhibit a fibrous texture similar to that of an ash stick when broken.

Iron for turning purposes is mostly made from scrap, in order to get it as clear as possible, and at the same time free from the seams common in piled iron.

The softest, and also the clearest iron for turning for cotton and other machinery, is made from wrought iron swarf (or turnings). Sometimes the swarf is worked by itself, but commonly a ball is made of good scrap, and while hot, fine swarf is thrown into the furnace, and the ball is rolled about so that the swarf adheres to it, and it is then taken to the hammer. Piston rods and other important parts of machinery are made from faggots of iron bars drawn under a use hammer, and frequently are twisted, in order to prevent the fibres and seams of the iron from running in the direction of its length, and also to make it more regular in its wear.

Some few years since I read before this society a short paper, which is printed in its transactions, "On Molecular Changes in the Constitution of Wrought Iron;" a subject which has since been investigated by the British Association. An extraordinary change is produced in iron by long continued vibrations, or shocks, or blows of a hammer, but I am not aware that it has hitherto been satisfactorily accounted for. It appears to take place more readily in scrap iron than in other kinds, and especially if there are many fillets or collars, or other inequalities, these appearing to destroy the uniformity of the vibrations, and so assist in inducing a re-arrangement of the molecules. If a shaft or bar be swaged or turned at the end, either larger or smaller than the other part of the bar, and it be struck at the opposite end with a hammer, the probability is that the former part will fly off after a very few blows have been struck, unless it be held in the hand, or unless the increase or decrease be very gradual.

By plunging iron when red hot frequently into water, the fibres will also lose their form and become quite crystalline, and as brittle as cast iron.

If two pieces of wrought iron work together without lubrication, a kind of union takes place between some of the particles, and the surfaces of the two pieces are torn and galled in a surprising manner. This is termed by mechanics "seizing," and is a source of great annoyance to them, as it will sometimes happen while fitting portions of machinery together. Mr. Samuel Poole, a young engineer in our employ, told me that he had seen a cross head seized on the end of a piston rod, so that it was utterly impossible to move it, except by a hydraulic or some very powerful process.

It is remarkable that most red short irons are tough when cold. This is the peculiar quality of the Welsh irons in general, but there are some both red short and cold short. The best South Staffordshire irons are neither cold short nor red short.

The defect of red shortness is generally attributed to the presence of sulphur, cold shortness, to phosphorus, and difficulty in welding, to arsenic. I have some reason to believe that the addition of flue cinder in the puddling furnace tends to counteract red shortness. With respect to others of the defects to which I have alluded, we can explain some by the process of manufacture, some we can only guess at, and of the causes of some we are quite ignorant. Two conclusions alone appear to be undisputed, namely, that extremely small quantities of extraneous substances in chemical combination with iron, produce most striking alterations in its quality, although such quantities of extraneous substances may be so minute as almost to elude the analysis of the scientific chemist; also that many of the qualities of iron depend on the particular arrangement of its molecular particles, which may be influenced and altered by merely mechanical operations.

Mr. Blackwell says that the gross annual production of iron in Great Britain at the present time is upwards of 2,250,000 tons; of this quantity South Wales furnishes 700,000 tons, South Staffordshire and Worcestershire 600,000 tons, and Scotland 600,000 tons. The remaining 350,000 tons are from North Staffordshire, Shropshire, Derbyshire, Yorkshire, and various smaller districts.

The first process in making iron is its reduction from the ore, which is roasted or calcined in a heap with coal to expel water, sulphur, arsenic, and such other extraneous matters as can be easily volatilized, especially carbonic acid. The ore is mixed with certain proportions of fuel, (charcoal, coke or coal,) and smelted in a large and lofty furnace, termed a blast furnace, so called because the combustion is supported by a powerful blast of air driven into the furnace by a steam engine. Charcoal is now almost entirely discarded in England as a fuel, on account of its cost, though it unquestionably produced better iron. I am disposed to believe that the principal advantage of charcoal arises from its being the purest fuel, because the next best iron is that made with anthracite coal, the next best with coke, and lastly with raw coal, the other materials being the same; and in the same order each of these fuels contains, each in succession, a greater quantity of sulphur and other extraneous ingredients, in addition to the carbon. Nevertheless some chemists have suggested that iron which has been manufactured with wood charcoal, may *probably* contain potassium, and may owe its superiority to this circumstance. Chemists appear, however, hitherto to have been puzzled in explaining the phenomena of both iron and steel; for although the best steel is made from iron which has been procured from ores containing manganese, yet careful and skilful analysis, as far as I know, has not been able to discover manganese in steel. I may also state what I believe is now no secret, that in the processes of improvement by which some English irons have been rendered fit for conversion into steel, manganese is a principal ingredient.

The produce of the blast furnace is the cast iron, commonly called pig iron, or pigs. This pig iron is readily fusible, and is employed in castings for a vast variety of articles, from the bridge over the Thames, to the shirt pin and brooch. Its qualities are as various, but concern my present purpose only as connected with the qualities of the malleable iron made from it. Pig iron, in addition to carbon, is supposed to contain oxygen, silicium, and probably many other minute and variable alloys. Potash exists in almost all our coal measure ironstones. Cyanide of potassium is frequently produced in considerable quantities in the blast furnace. The most apparent differences in pig iron are discovered in its colour; as a general rule, the blackest contains most carbon, the grey and mottled less, and the white pigs the least. But there are important exceptions. Some of the most highly carbonized pig iron is light in colour. Its darkness seems to vanish if carbon be present in great excess, as in the case of "greasy irons," the crystals of which are small, and assume a soft or greasy appearance. The colour is also very light. Pigs made from charcoal often contain in their centre patches of white iron, which is highly carbonized; so that the general formula must be considered as correct only in reference to irons made from coal or coke.

Until within the last twenty years, the pig iron for good qualities of bars was re-melted in a furnace called a refinery, blown with a blast of air, and run into thick plates, which plates were afterwards broken and then put into the puddling or reverberatory furnace. This refining process is not simply a re-melting one, as the iron, when melted, being exposed to the action of a blast of air, the oxygen thereof combines with some of its carbon, and thus partially effects the operation subsequently perfected in the puddling furnace. Moreover, it is probable that some of the impurities of the pig were got rid of, as well as a portion of the carbon, such, at least, as, being lighter than the iron, floated on the surface, and when run into the slabs or plated, flowed off into a hole scooped out at the foot.

The intermediate process of refining is now generally abandoned in Staffordshire, the same objects being attained much more economically by an improved method of puddling, termed boiling.

Heating the air before it is driven into the blast furnace, commonly called "hot blast," has effected most extraordinary results in increasing the quantity of iron by economy of fuel. I well remember the protracted discussions to which the hot blast question gave rise in this society some years since, and I have no desire to renew them; but I must state my conviction founded on long experience, that the hot blast does in some respects, and for certain special purposes, deteriorate the quality of the iron made. It is conjectured that this arises from the greater heat of the blast furnace effecting the reduction of certain earths into their respective metalloids, especially silicium, and in that state that they become alloyed with the iron.

The puddling furnace is a reverberatory furnace. The man who works it is called a puddler, and is assisted by an under hand. The bottom and sides of the improved puddling or boiling furnaces are made of cast iron plates, which are preserved from fusion by a thick coat of protoxide of iron. It is a great desideratum to find some more refractory substance for the bottom of these furnaces. A very great number of unsuccessful experiments have been made. I tried once to make a bottom of fire brick, but it wore away rapidly at the joinings of the bricks. I then attempted to make the bottom of a single huge brick, but although great precautions were taken in the admixture of powdered coke and in the drying, I did not succeed in getting my brick made without numerous small cracks, from the unequal contraction of so large a surface of fire clay. Platinum might probably answer, if it should ever become abundant and cheap enough. Hot blast pigs have a much greater tendency to destroy the bottom of the puddling furnace than cold blast pigs. I once tried a sample of hot blast pigs, which destroyed the bottom of the furnace so rapidly, that a hole was burned through, and the melted iron ran down into the ash pit. It was this property of hot blast iron of destroying the bottoms which rendered unsuccessful my attempt to introduce an improved description of puddling furnace at the large iron works in the south of France, in 1837. We account for this by guessing that hot blast iron contains silicium, and that, acting on the protoxide of iron which protects the iron plate of the puddling furnace, converts it into an extremely fusible matter, namely, silicate of iron. The operation of puddling is one which requires great care on the part of the workman in reference to the quality of the iron produced, and also in reference to the yield, as it is termed, or the quantity of finished iron produced from a given quantity of pigs: this will vary much according to the quality of pigs used, form of furnace, character of fuel, and skill of workmen. It is now generally considered that 22 cwt. of pig iron is required to make 20 cwt. of puddled bars, and about 21½ cwts. of puddled bars to make 20 cwt. of the finished merchant iron. Some idea of the improvements effected in this department of the manufacture may be formed from the fact, that when the system of puddling was first introduced, 33 cwt. was required to produce the same quantity of merchant iron now made from 24 cwt. of pigs.

The peculiarities or properties to which I wish further to advert, are *body*, *soundness*, *clearness*, *toughness*, *hardness*, *and softness.*

First, as to *body*. This term is applied both to iron and steel in a very loose and indefinite manner, but I believe is usually meant to imply the property of bearing considerable and repeated action of fire without becoming brittle. It is a most mysterious property, and chemistry has not yet been able to inform us on what conditions this property depends. The manufacturer of bar iron knows, however, that it exists in some kinds of pig iron more than in others; that it exists less in hot blast than in cold blast pig iron, and least of all in those pigs in the manufacture of which any considerable quantity of silicate of iron, termed cinder, the refuse of the forges, has been used. It is one of the most essential parts of the education of a skilful iron master, to learn what mixture of pig iron of various kinds he can most economically use, to produce precisely the sort of iron which he requires for special purposes. At my brother's and my works, at Leabrook, Tipton, where we employ twenty-two puddling furnaces in making only special kinds of iron, there are frequently many adjoining furnaces, each with a different assortment of pigs; and it is necessary for this purpose that we should keep an assortment of pig iron from various parts of the kingdom, and even from India. A great deal of iron in Staffordshire is what is termed double worked or ball-furnaced; that is, it is cut down, piled heated in a furnace in the forge (usually on a sand bottom) called a ball furnace, taken to the hammer, shingled, and rolled into a bar, which is again cut down and piled in the mill, sometimes only the top and bottom, and sometimes the whole pile, being formed of this reheated iron; the object of this additional process being to give the iron sufficient tenacity and malleability to roll without cracking, into angle and T iron, and a great variety of different shaped bars, used for particular purposes, and commonly termed fancy iron. The top and bottom piles of rails are always ball-furnaced. The ball-furnace is also used for working up scrap into bars.

Soundness.—Unsoundness is perhaps not a mystery, but it is, nevertheless, still a desideratum to know how to make *perfectly* sound iron without a great additional expense of manufacture. The larger the bar, the more difficult to make it perfectly sound. The unsoundness consists chiefly of a thin layer, or of particles of protoxide of iron. All iron heated to a certain temperature becomes immediately coated with the blue protoxide of iron, which is an obstacle to perfect welding. The use, I believe, of borax in welding, is to form a flux to this protoxide, which being then squeezed out by the blows of the hammer, two surfaces of pure iron being brought into perfect contact, a perfect weld ensues. All the holes and inequalities of the puddler's ball, as soon as it is drawn from the furnace, become immediately covered with a thin film of protoxide of iron; this is doubled in under the shingling hammer. Then again the puddle bars all become coated with the same blue film, and when heated together in the furnace, so much as does not run out in the furnace, or get squeezed out between the rolls, prevents a perfect weld, and renders the iron unsound. In the manufacture of steel, what is termed unsound iron blisters very much in the converting furnace. This is probably because the carbon, penetrating into the pores of the iron when it meets with the protoxide, forms carbonic acid gas, and thus blows up the blister. On the table is a piece of Swedish bar steel, exemplifying a very large blister.

Clearness, the absence of greys or small cavities.—These cavities are possibly also occasioned by particles of protoxide of iron which have been volatilized at a high temperature. This is the more probable as scrap iron, although very tough, which I attribute to the interlacing of its fibres, is very full of greys; and in making very tough iron, required to be free from greys, the scraps are scoured bright by a mechanical process previous to being worked; thus cleaning off the protoxide, and the red or per-oxide. Gun barrel iron is required to turn clear in the interior, otherwise the friction against these small cavities rapidly destroys the evenness of surface.

Toughness.—This quality in a great degree appears to depend on the mechanical arrangement of the molecules of iron, because a bar of granular iron of good quality, if further drawn out, will become fibrous. Moreover, the most fibrous iron will lose its fibre under circumstances which appear to favour a re-arrangement of the molecules; for instance, the iron being subject to too great a degree of heat, or burned, as it is termed, or as I said previously, being cold swaged, that is, gently hammered from a yellow heat until it becomes only lukewarm. It might be a curious question how far the quantity of latent caloric may vary in various irons, and how far their properties are modified thereby. It is now an admitted fact that fibrous iron may become granular under the influence of vibration, and, therefore, I think it is presumable that toughness depends on the molecular arrangement of the particles; but why certain ores and fuel should invariably produce an iron which has a strong tendency to the fibrous molecular arrangement, and other ores have as constant a tendency to the crystalline or cold short molecular arrangement, is a question which I have never been able to obtain the slightest explanation of. It is true that sulphur is said to contribute to the one, phosphorus to the other; but why?

Hardness.—This certainly depends in a great degree on more or less of carbon being left in the malleable iron, but also, I imagine, sometimes on the presence of other bodies, among which are silica or silicium, sodium, or chloride of sodium, and potassium. It also may depend on the specific gravity of the iron, which we know may be manufactured so as to present either a very compact or a very porous texture; and accordingly the specific gravity of both iron and steel has been found to vary considerably in different qualities. Softness may arise from extreme purity. The charcoal iron of Biscay, in Spain, is, I believe, considered the purest iron made, elsewhere than in the laboratory of a chemist; it certainly is the softest.

A subject like that which I have brought before you this evening might be indefinitely prolonged. There are a great variety of irons used for special purposes in Birmingham, which I have not named, nor have I even alluded to the multitudinous descriptions of irons which are employed in the manufacture of steel of various qualities; but at this point I have read over and timed my paper, and I find that it will occupy so much of our meeting this evening as only to leave time for the remarks of some of our members, much more competent than myself to have undertaken the subject.

A short discussion followed, after which the Chairman called for the next paper announced to be read, which was—

ON THE CHEMICAL PREPARATION OF FLAX FOR MANUFACTURING PURPOSES. BY THOMAS JOHN PEARSALL, F.C.S, CONSULTING CHEMIST TO THE NORTH LINCOLNSHIRE AGRICULTURAL SOCIETY, &C.

When the subject of the meeting of this society in Leeds was named recently by some of its ardent friends, the desire was also expressed that some papers should be brought forward with reference to the staples of the town and neighbourhood, rather than upon purely scientific details, which could find other channels. As I had recently seen most of the best plans for preparing flax in Ireland, &c., I thought an account of some new chemical processes might call the attention, and deserve the discussion, of those who wish manufacturing skill and scientific truth and advantage to be united.

With this view the subject is brought forward, and the specimens will show that means have been taken to make it as practical as a paper may be, where trade processes are alluded to; and yet with no wish to advance into prominence any individual or plans, except so far as they conduce to the general bearings of the subject.

Before men so conversant with flax, and with such ample endowments for manufacturing appliances, I may give for general purposes a short account of flax and its processes, before I solicit their attention to any special points.

The flax plant, growing so extensively as it does, and in so many climes, has a name in the earliest histories, and even the "figures upon the wall" of the Egyptians show that the processes for obtaining the fibre were very similar to those employed even in Great Britain at recent periods; and when drawings are shown of the rude instruments that have been employed in Ireland, and the means to separate the fibres are understood, the processes of manufacturing flax would seem not only to be simple, but to have been followed for ages in different climes throughout the world with great similarity; indeed, the end to be obtained,—the separation of the fibres from the plant, and the combination again of these into thread, and the threads woven into linen,—seems to have been easily carried out by the Egyptians to such perfection that, rude as may appear their instruments, yet it is found that mummy cloths have been made of so fine a texture as to rival the finest cambric produced by the unexampled combinations of capital, machinery, and energy of our present business times, aided by all previous examples. It has required the microscope and the practical skill and investigations of Mr. Thomson, of Clitheroe, to settle all doubts upon the subject of the skill of the ancient Egyptians.

That country, early renowned for its "fine linen," now yields a flax among the coarsest in commerce, and, with our machinery even, is incapable of being woven into fabrics half so fine as are found among the tombs and mummies of Egypt, woven thousands of years since, and with simple means. The whole processes of the growth of flax—the preparation of it—the implements employed—the attitudes of the labourers—and the specimens of complete work, are all exhibited to us by the remains of pictorial art upon the walls. The actual fibres of materials are preserved by chemical power, so that at the present day we can well contrast the early history and practice of Egypt, with the workmanship of living people.

Wide-spread as the flax plant is, and hardy as is its nature, yet it yields its abundance of proper fibre in the stem for manufacturing purposes, after its growth in suitable soil and circumstances of season, and attention to the periods of its ripeness.

The culture of flax, probably, has never received more attention than at the present time, and the amount produced, and the still more abundant demand, show that it is now a subject of national importance. Probably there never was a period when the production of flax has been so great as within the past few years. Hence the knowledge of this plant, the means for successful production, and cost and profit of a crop, are matters that relate to the landowner, the agriculturist, and the manufacturer. In this society a paper has been read on the Policy of Flax Culture, by Mr. Briggs.* The importance of the crop of flax to the grower is there stated, and may be consulted by those who will also now have the advantage of more recent statements of Mr. MacAdam, Dr. Hodges, and the flax literature of Ireland; indeed, every year lately has been the means of recording the results of experiments, or developing by means of literature the trade and commerce connected with this plant. The Royal Society for the Growth of Flax in Ireland, the Belfast Flax Society, and the "Journal of the Chemico-Agricultural Society of Ulster," (to say nothing of the labours of particular men, the energy of patentees and the teachers, grants and prizes for especial merit, in relation to flax,) now afford a clear insight into the nature of the simple practice hitherto followed, its irregularity and waste, and the desire to get true knowledge for capital and skill, to legislate for extended demands and supply. The practical man will have in these references the means of ascertaining how far Ireland has increased her resources, with judicious plans and industry, capable of affording useful examples elsewhere.

The flax plant *(Linum usitatissimum)* is grown in most countries, and while Ireland is increasing its crops yearly, and the general production of flax is great, yet in England the quantity grown is so small as scarcely to admit of comparison,—so small, indeed, that it is considered as an experiment, and as a curiosity of crop culture among agriculturists. Yet England has to import enormously of flax, and her manufactures, commerce, and comforts are much dependant upon flax; the true value of this crop ought, therefore, to be immediately known to the farmer.

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* See Vol. II. page 429.

The flax plant is grown in most countries for two purposes,—one for the plant to furnish fibre from the stem—the other for the plant to furnish seeds; and history assures us that countries are to be found at the present day that grow vast crops for the one purpose, utterly careless of the other. In India, where the seeds are used for the purpose of obtaining oil by expression, there the natives refuse to obtain the fibre from the stem; while in Ireland the early culture of flax for the fibre alone, and the production of thread and linen belonging to their tradition, the seed is there thrown away and disregarded; indeed, the enormous value of this waste could neither be estimated nor believed, if we had not the true data afforded us. But societies have been furnished with funds, printed instructions circulated, travelling agents sent to speak and teach, and public boards and meetings held, to subdue this extent of ignorance and prejudice. Of the necessity for education, and to explain the value of scientific appreciation to eradicate the habits fostered by prejudice, few examples can be quoted more to the point, perhaps, than the language of the Royal Flax Society of Ireland, which declared, in 1850, "That the value of the seed of Irish flax crops during the ten years of the society's labours cannot be estimated at less than £2,000,000 sterling; of this large amount, probably not more than one-tenth had been rendered available, the rest having all been steeped with the flax, and thus utterly lost." Other statements up to the present time show that prodigious waste occurs with the present crops of Ireland, notwithstanding the grant of £1,000 annually from the public funds for the promotion of true knowledge of flax, the circulation of 6,000 copies yearly of instructions for saving seed, the analyses that have been made, the suggestions and reports, the efforts of seventeen paid travelling instructors, and the teaching of the professors in the college and schools. One society states that it believes it has been the means of saving seed to the amount of £300,000 sterling since it began.

The flax plant, when gathered, about July or August, is pulled up by the roots, and may either be stacked when dried, in small bundles, or the plant stems may be thrown into pits, or pools of water. This is the usual practice. Here the plant lies for two or three weeks, until fermentative and putrefactive changes take place that enable the fibres in the stem to be readily separated one from the other, and also from the wooden centre of the plant. All over the world the plan seems to be nearly the same: select quiet water, throw the plants into pits or pools, ditches, or rivers; allow them to remain there until decay has separated the gums and tissues that bound the different parts strongly together, practically testing the stage of the progress by snapping the woody stem, and separating readily with the fingers the fibres that run on the outside, from one end of the plant to the other.

The flax plant has a slender stem, and the height varies with the character of the seed and climate, and may be said to be from eighteen to thirty inches, and some specimens much taller. When a flax plant is examined, we can readily distinguish by breaking—1st, the wooden cylinder, that is, the bulk of the stem, and upon it, and 2nd, around it are the fibres; these are cemented together by a peculiar matter, a sort of gum, which, being thoroughly incorporated in every portion of the fibre, binds also each fibre together, and thus makes a cylinder of separate pure fibres to surround and adhere to the woody cylinder inside the plant.

The different kinds of flax are sown for different purposes, and if need be, are watched with judicious care in every stage, from the selection of the seed and adaptation to soil, so that all the plant shall be of like growth in length, to the care of weeding out, and the preservation of the young plant, and the precise time for pulling up, if very fine fibre is required. Some varieties grown in Belgium, and, indeed, elsewhere, have a degree of attention that would scarcely be expected to be required by a plant that grows in nearly every country.

I have seen in Holderness some lands growing fine tall flax, with its beautiful and delicate pale blue flowers. By the sides were stakes, and upon these were spread nets over and above the heads of the flax. It was reported that a foreign flax, of peculiarly fine fibre, could be grown close, aspiring upwards to the light, yet so slender and delicate that the winds would easily break down the fragile slender stalks; to remedy this, stakes are said to be driven, and tarred rope and other support given, that the crops may not be cast down by the wind. How far this system is advantageous, of spreading light net work to protect from the wind, and act as "artificial clouds," I cannot say, but I name it as a beautiful experiment, whose repetition and results are due to the Messrs. Marshall, of Leeds.

If the entire plant be subjected to burning, it is found by Sir R. Kane to yield about 5 per cent. of ashes; the 95 per cent. consisting of oxygen, hydrogen, and carbon, and a little nitrogen.

The pure fibre, the flax, contains but little besides a trace of ash; the gum and the woody fibre, but especially the gummy cement, contain the great proportion of saline and solids.

The object, then, of steeping in water will now be readily understood; it consists in softening and ultimately dissolving out this glutinous gummy matter, and by fermentation breaking up small vessels that are interwoven like a net with the long fibres; a sort of putrefaction or decay is induced, so that each portion should readily yield its constituents—thus, the gum, sugar, and juices, by solution and fermentation, are dissipated from their original vessels, and the long fibres are capable of being separated from each other, and from the woody cylinder, still strong enough to keep them together, but not brittle enough to injure these natural threads.

In early times there seems but little doubt that the flax was pulled at once from the dried stems and woven into threads; but use, and time, and damp, would soon show the presence of the rough and gummy matter, and to avoid inconvenience from this seemed to be a first stage. Flax has at different times been proposed to be used in the dry way, but except for coarse purposes it presents objections; the fibres are bound together by a glutinous matter that cuts when dry, and irritates, and also attracts by moisture dusty matters, thus making articles of a thread nature variable in quality, offering inconveniences, and subject to damp.

We can now understand that water, aided by a moderate temperature, and without the violence of a stream, can readily dissolve out these matters which by fermentation mostly become gaseous, or combining with carbonaceous and earthy matters, form a slime. This is probably the reason why certain waters are preferred, and the freer from earthy impurities the better; and if a current at all, one so gentle that the bulk of the flax and the fermentation would disengage the juices and the gases: thus, in fair soft water the fibres readily separate from each other, and have a silky feel; they are capable of being more easily spun into finer linen, and bleach more readily, than where earthy waters prevail.

This will at once explain why certain waters and rivers have been justly preferred for this process. It will be found that, for small quantities, rain water in pools or ditches answers well; indeed, to get the fermenting change, we can understand why sometimes old leaves have been added to form a sort of fermenting mixture. In the great rivers in Belgium and France, it may be found that the character obtained for these streams is not only due to the temperature and comparative purity of the water, but the whole stream is one vast volume of matter, floating about, undergoing putrefaction and decay. Dr. Hodges found by samples of water taken in the depth of winter from the River Lys, bordering France and Belgium, that the whole stream might be considered as charged with the vegetable matter in decay; so large is the quantity of flax steeped therein, and so constantly used is it for the purpose. Other analyses tend to the view that of the salts the river contains, some have the tendency to make the "flax gum" more soluble than it would be in pure water.

In these rivers the flax in bundles, and those placed in frames, are sunk in the water, and the changes of decay take place, the water is rendered polluted, and the air contaminated with evolved gases. In the neighbourhood of flax ponds, most persons must have been affected by the disagreeable odours, and on the large scale the air and water may be said to be loaded with poison. This is so well known that local experience has shown the necessity for laws to prevent the streams to be preserved for fish from being polluted by the flax waters; and the evidence in Ireland, showing the entire destruction of fish by the admission of flax steep waters, is also well known.

The management of the flax so as to yield the most fibre by careful growth and culture, and the selection of proper time for pulling and for remaining in the water, with the due conditions of maturity of plant, stages of decay, and power of the water and of the heat of the atmosphere,—all these may be summed up in few words, but the best practice requires experience, care, and time. At the critical period of steeping the examination is made, to observe the facility of separation of these delicate fibres, readily, the whole length of the stem. It is stated that a few hours will make a great difference in the strength of the fibre, and consequent quality in work and value of the flax.

The immersion of the flax in water to steep, the putrefaction of some portion, the solution of soluble salts, the evolution of gaseous matter, and the suspension of earthy salts with carbonaceous refuse and organic life, are changes to separate the parts of the plants, which, after a period of time,—from seven to twenty days,—are taken from the steeps and water, and laid upon the ground, there exposed to light, to air, to changing temperature and moisture, are properly dried, and thus constitute the "retting" of flax. In this old and usual way, it will at once be seen, that with water charged with salts of iron, and with organic matters and lime, the colour and other qualities may be easily altered by cold water retting, and the old pits made and kept for the purpose are becoming more and more unfit, such practice brings no remedy by experience and time.

The critical examination of the straw of flax has recently been undertaken by Dr. Hodges, of Queen's College, Belfast, with due reference to the analyses of Sir Robert Kane and others; and as he gave his valuable results to the British Association at Belfast, in a well considered paper, since published, I refer to his results in the following table:—

COMPOSITION OF THE INORGANIC MATTERS OF THE CROP OF FLAX.

100 parts of the ash of flax straw and the capsule, without the seed.

	Ash of straw.	Ash of capsule.
Potassa	20.32	16.38
Soda	2.07	6.25
Chloride of sodium	9.27	12.98
Lime	19.88	13.95
Magnesia	4.05	3.94
Oxide of iron	2.83	0.38
Sulphuric acid	7.13	14.51
Phosphoric acid	10.24	23.26
Carbonic acid	10.72	6.37
Silica	12.80	0.67
	99.31	99.66

Dr. Hodges, by constant reference to an experimental crop, has been enabled to give some very valuable results. He finds that the fresh plant, distilled with salt and water, yields a peculiar volatile oil, of a yellow colour, having an agreeable penetrating odour, like that of the atmosphere of a room storing flax. About five pounds of the plant yield about ten grains of the oil. By bruising the straw and macerating with successive solvents, as ether, alcohol, acids, &c., the proximate constitution of fresh straw of flax may be thus stated—

Volatile oil of flax.
A fixed or fatty oil.
Traces of chlorophylle.
A peculiar green resin.
A gum resin.
A modification of tannic acid (precipitating per salts of iron grey, but not affecting some other tests.)
A peculiar gum, not affected by borax or silicated potassa.
A brown colouring matter.
Albumen.
Casein.
Starch.
Pectine.
Cellulose, and various salines.

The following table will be very useful, and interesting to show the power of different solvents on the flax plants, to extract these different substances:—

	Grains.
1. Soluble matter in ether	2.83
2. Soluble in absolute alcohol	3.52
3. Soluble in water	5.92
4. Soluble in dilute hydrochloric acid	22.76
5. Soluble in dilute caustic potassa	16.39
6. Cellulose and salts	48.58
	100.

Dr. Hodges also gives the weight of the flax plant at different ages of its growth. Thus, on the 28th of April, 1851, the young plants appeared above the ground; on the 10th of August a plant is thus described—

Entire length, with root, 37 inches.
From surface of soil to branches, 29 inches.
The stem light straw colour.
The leaves withered, and attached on 10 inches of stem.
Capsules, 10.
Seeds, green.
Weight of entire plant, 71 grains.
Weight of branches and capsules, 31.8 grains.
Water in plant, 45,336 grains.
Solid matter of plant, 25.665 grains.
Inorganic matter of plant, 1,066.

PER CENTAGE COMPOSITION OF FLAX.

	Fresh plant.	Dry.
Water	63.852	......
Organic matters	34,732	96.08
Ash	1.416	3.92
	100.	100.

On August 25th, the crop was pulled; one plant was taken:—

	Grains.
Weight of entire plant	62.40
Do. capsules	22.50

PER CENTAGE COMPOSITION.

	Fresh plant.	Dry.
Water	56.64	......
Organic matters	41.97	96.89
Ash	1.39	3.11
	100.	100.

The above will indicate the advantages of that extended investigation which may do much to remove the obscurity of the practice of ages, and throw light upon operations dependent upon changes which the practical man must be able to appreciate, yet finds difficult to describe, and, indeed, impossible to explain, until the full chemistry of flax is known.

Various methods have been suggested to enable the change of temperature and time to be estimated, and rapidly or certainly discharge the matters bound up with the gum, or to lessen the risk of rottenness of the fibre. Chemical solvents frequently diminished the time, but changed the fibre from a glossy hue and silky quality to one unpleasant and harsh to the touch. Steeps of chemical alkalis, and nostrums of all kinds, have been tried without producing much general change, improvement, or profit.

The plan of "retting" by means of warm water, and a uniform and desired temperature, was introduced by Mr. Schenck, of New York, into the county of Mayo, about 1848: it is a plan that offers peculiar advantages. The flax plants are first collected and then dried, then the seed is taken from the plants, and the retting of the plant is performed by the bundles of flax being placed in large vats, and kept down by weight or pressure; the vats are filled with water, and steam, passing through pipes, gives the desired temperature. Thus, the fermentation can be accelerated and controlled, all the uncertainty of the cold steep plan is removed, by attention for three or four days instead of as many weeks, while more equality of fibre is obtained:

the quality and yield also are greater than on the old plan. The Flax Society reported that Schenck's plan yielded 20 per cent. quantity more than by the old steeping, and in working fineness, Schenck's had greatly the advantage; in quality, the market value, too, was stated to be, Schenck's £12 10s. per acre, against £9 8s. on the old plan.

There are about twenty retteries in Ireland, on Schenck's plan, and in England the plan and modifications are in use; it is, however, admitted that the Yorkshire practice is more continuous, and most capable of ascertaining the full cost and advantages or disadvantages and expenses of this mode of working. Few as may be the flax works in England, yet some are more perfectly carried out than any in Ireland.

By this judicious application of simple regulation of temperature, it seems that there is at once a new feature introduced into the flax trade. The grower of flax no longer need become a most imperfect manufacturer, with imperfect appliances and slovenly help and waste, with air and water spreading dismay or infection around. There are now introduced the very elements to excite confidence in capitalists, viz., that the flax should be purchased as a marketable article, and machinery, vats, and labour be applied, constantly, to stores of the material. The saving of seed, the storing of the plants, the purchase of crops, and the attention to the processes, conducive to the quality desired of flax fibre, have thus been brought before the interested capitalists of land and machinery.

In 1850, six thousand bushels of seed were thus saved from the dried plant, and sold from the steeping concerns; and the calculations were that 40,000 bushels would be the result to be looked for in following years as saved from absolute waste.

With the introduction of regulated volumes of water and temperature, the obvious experiments again arose for the use of appropriate solvents. Chevalier Claussen patented plans for the use of boiling alkaline solutions, and proposed to reduce the time to twelve or twenty hours for "retting" the flax chemically. An inspection of the diagrams shows the modes of stocking the vats, steam power, and the general arrangement of a "rettery" on Schenck's patent process; and having seen, perhaps, the best in Ireland and England, I may speak of the elegant arrangement, and the completeness of the process to the careful observer, while the improvement in the atmosphere and the precision of machinery and premises offer a complete contrast of business, skill, and capital, to the slow, wasteful, and pernicious plans of old.

The introduction of the thermometer, and constant observation, will do much to create the true men for work. The steam is allowed to enter at temperatures from 80° to 90°, and so delicate is this flax plant, and the whole process, that it is not yet decided what is the precise degree of heat that is best, whether 80°, or below it. Much depends, perhaps, upon the crop, the atmospheric changes, and whether the vessels are covered or not: the ultimate uses of the flax are also to be regarded. Again, some persons steep once and some twice; some wash the flax, after steep, with clear water; others remove with the supernatant fluid adhering: then in the drying, some dry rapidly under cover, others spread out to light and air, on the grass.

There is no doubt that a peculiar fermentation is set up in these vats or vessels. After the process has been carried on in the vats, and the water allowed to cool, a peculiar *scum* has been observed, a sort of dusky film, which spreads upon the surface of the fluid.

Professor Allman has minutely attended to the changes that take place, and, with the aid of the microscope, finds that when the flax and water are raised to 90° in a few hours, the liquid becomes of an amber colour, minute organisms or corpuscles are seen; these aggregate and change, and ultimately by transverse processes, chains of cells are produced in such numbers that the water becomes turbid, and there results a peculiar fungus, recognised as occurring in the fermentation of albuminous liquids, and this fermentation may be viewed as a vegetating process. During the vegetation and production of these cells, a peculiar odour is observable, and this Dr. Hodges traces to the formation of Butyric Acid and Butyric Ether. Other odours are observed, and are so like a brewery that he was induced to try by some direct method to ascertain if alcohol was present, but he obtained no proofs of the presence of alcoholic spirit.

The peculiar fungi seen in Schenck's process occur readily under certain conditions. In vats of some material, as slate or iron, it is never seen at all; in wood, it takes place slowly at first, indeed in new works and in new wood vats it is never seen at all in first working; while in works of constant use, the odour, and the scum of cobweb-like appearance, are probably the circumstances to strike a stranger at first entrance. It is suspected a practical use may be found for these results; that fermentation in vats may be accelerated from any cause when it is tardy; some of these cells may be placed in the vats, and then the fermentation be accelerated by this vegetation. It is probable that in new vats the cells developed adhere to the new wood, and to the surface of the flax. The experiment of artificial vegetation or fermentation has been actually tried with success, and it is probable that the water of the famed rivers of Lys and Courtrae may not only be charged with these cells, spontaneously produced by the previous decomposition of flax, but that the sides of the rivers, the weeds, the very mud, may also afford myriads of these cells, that immediately find appropriate material in the flax placed purposely to decay; and thus observation and natural science may clear up the difficulties of practice and chemistry, even when associated for years, where other influences, and especially that life, prevails.

I might at this point advert to plans and patents that have been taken up by individuals to obtain results more or less connected with the principles of chemistry, or the labour and capital involved in the full working of Retteries on the plan of Schenck. Having submitted to you samples of the old plans and of the new, I have now the last new process patented by Watt, of Glasgow, carried out by Messrs. I. Leadbetter and Co., at Belfast, and the Croy Mills, near Glasgow, and which offers such efficiency that it may well demand attention. The whole plan seems simple in theory and inexpensive in practice, easily arranged and kept in order, apparently economical, and the results peculiar and successful. Here the flax straw, previously divested of seed, is placed in an iron box or chamber, made tight; on the top or lid is a cistern of cold water, and inside is a false iron bottom perforated, and about a foot above the real bottom of the chamber or cistern. On this the flax bundles are placed. Steam at low pressure is then thrown into the box by means of a pipe round the inside and beneath the shelf of the box. The first operation of the steam is to evolve and distil away the oily and fatty matters of the plant, penetrating and raising the temperature of the mass of the flax plant. As the steam rises to the top of the box, it is condensed and falls as pure water, which passes through, and saturating the softened plants, dissolves out all the soluble matters, which trickle through to the apertures of the false support, and the solution is collected. Steam continues to be admitted, to condense into rain, constantly washing with pure water the plants, and from time to time the extracted matter is run off by means of a pump; the early portions affording a strong mucilaginous mixture, available for feeding.

In from eight to twelve hours the process is complete. The plant, thus deprived of its soluble matter, is passed through and between heavy rollers that at once detach the epidermis, and separate the valuable fibre from the woody material, discharging the fluid in the saturated straw, which thus wetted yields the separation of the fibres readily in the direction of their length by the use of the rollers. The straw thus mashed, macerated, and split up, is easily dried, and in a few hours is ready for the mechanical operations. It will thus at once be seen that mechanical skill and chemical principles are at work with efficient power. The flax, it ought to be stated, is first crushed by passing the bundles of flax between iron cylinders, to separate the seed bolls. The plant is thus crushed open, and admits in the iron box the pure solvent distilled water, which dissolves out all the soluble portions. Thus the flax differs materially from all those processes which involve *time* and *air*, by being a process of disintegration, and not of decay and fermentation. Hence we are prepared to find that the matter exhausted is sweet, and can be used for feeding purposes.

When first drawn, the more concentrated fluid has the colour of porter, but has a thicker and more glutinous body, and while its odour and taste are peculiar, it is not disagreeable. In reply to the doubts and questions of its fattening power, and being acceptable, the prompt answer was, "let the pigs decide that point!" It is found that the fluid can be used as a feeding agent in the farmsteads, with turnips and other food.

The flax thus rapidly prepared has a fine complexion, and a peculiar odour, which with other points enables the practised man to detect the presence of flax prepared by Watts' patent by every sense of sight, and touch, and odour.

Into the working details I do not enter: it is to the principles involved, and the results obtained, that I would ask attention. It would be enough if it were only that sweet and wholesome substances were obtained, in place of those that produced danger to all who partook of the air and water so polluted on the old plan. Rapid action for hours, with powers easily managed, takes the place of seasons, and inconstancy at every step dependant upon climate and atmospheric changes; instead of slovenly labour and wide space, here skilled labour and machinery can operate, with spaces not larger than the bulks of the material to be stored up; in place of disagreeable sources of disease and decay, food of a beneficial kind is produced. Not merely are the compressed juices employed, but the seed bolls and chaff are used for food, and the less nutritious portion or woody fibre is positively used as fuel to raise the steam.

Schenck's plan had suggested the probable value of the steep waters, but the quantity of valuable manure is so small, and is dissolved in so much water, that it would not appear desirable to look to that as a source of return to the soil. One imperial gallon of Schenck's steep liquid contained—

Organic matters	136.7
Inorganic matters	132.4
Total	268.11 grs.

and of this solid extract about 1.56 grains is of nitrogen.

An imperial gallon would thus contain about 5 grs. of ammonia, and a vat of 3,000 gallons of water $2\frac{1}{10}$ lbs. of matter, worth about the sum of 1s. 2d. to the farmer; and the same bulk of liquid would give about the same small weight of phosphoric acid. The steep water is thus useless from its poverty of contents, and association with enormous volumes of water.

The liquid obtained at Messrs. Leadbetter's works by Watt's patent had an agreeable odour, and might have been considered as a "Tea of flax." Dr. Hodges obtained the following results:—

One gal. evaporated to dryness gave of organic matter...	353.97
Earthy and saline matter	163.83
Total	517.80

The organic matter yielded on analysis 14.79 grs. of nitrogen.

The earthy and saline substances had this composition:—

COMPOSITION OF ASH OF THE STEEP-WATER OF FLAX.

	Per cent.		In a Gal.
Potassa	27.17	...	44.63
Soda	3.18	...	5.12
Chloride of Sodium	21.58	...	34.61
Lime	5.91	...	9.49
Magnesia	4.60	...	7.40
Oxide of Iron	0.83	...	1.33
Sulphuric Acid	15.64	...	25.11
Phosphoric Acid	5.66	...	9.01
Carbonic Acid	12.43	...	19.96
Silica	3.	...	4.83
	100.	...	161.49

The samples, of course, may vary with the plant, and the slowness of steam maceration. Professor Anderson found the total solids to be in one gallon 1081 grs. Of these solid contents 375.5 grs. were inorganic, containing 17 grains of phosphate, the nitrogen of the organic matters 14.7 grs., corresponding to 93.3 of proteine compounds.

It will thus be seen that the soil can receive back the inorganic matter of the soluble contents of the juices and stem, the matter of the stalk and seed vessels, and even of the seeds themselves, formed into cake and used as animal food.

The woody "choves" or woody column of the stems, have been analysed. 1,000 lbs. of the choves yield 19½ lbs. of ash, containing, as most valuable ingredient of the soil, 10.43 per cent. of phosphoric acid. The nutritive matter thus extracted from flax, with the capsules (seed husks), and chaff of flax, are eaten with avidity, and this has called forth much attention to the feeding powers of the flax plant.

It is related that a cow fed upon the "Bolls" or capsules and chaff of the flax plant, and which gave from two and under three quarts of milk, when fed with the above food, gave nine quarts of excellent milk. To test the value of this peculiar food, the owner discontinued the flax feeding, and the cow soon fell off to four quarts of milk daily.

Sir Robert Kane has analysed the flax capsule dried at 212, and this gave 6.54 per cent. ash, and 100 ash yielding 5.74 of phosphoric acid, the husk is equal to 1.5 of nitrogen. It will thus be seen that it contains much of the important constituents required for animal life and vigour.

The nutritive powers of different substances, estimated by their most valuable ingredients, may be thus compared :—

NUTRITIVE COMPARISONS.

Wheat as	100	Flax Seeds	33
Oats as........................	51	Linseed Cake	70
Flax Capsules and Seed...	27	Dry Clover Hay	39
Flax Husks	22		

Linseed may be thus shown by analysis to yield in the different portions of—

	Ashes.	Phosphates.	Nitrogen.
Capsules........................	8.80	... 0.39	... 1.80
Husks	6.54	... 0.38	... 1.50
Seeds	5.18	... 0.47	... 1.81
Cake	8.67	... 0.81	... 2.25
Standard Wheat		1.13	... 2.3
,, Oats		0.60	... 2.2

It also results that about 2½ cwt. of dressed flax takes about 1½ lb. of ingredients from the soil.

Enough has surely been done by science within a few years to dispel that prejudice against the crop which is said to prevent its culture in England, viz., on account of its exhausting power. On the old system the materials taken were lost, and life destroyed; on Schenck's plan, too dilute and too poor to pay to add to land with any chance of benefit; but by Watt's process, a new food is found, and the valuable phosphates and nitrogenous compounds are returned to the soil with the most suitable conditions of fertilizing power.

Thus our farmers are invited "to fresh fields and pasture new" and profitable.

Among the most recent plans of chemical action to aid the flax processes, are those now much named by the press, by the Chevalier Claussen, to prepare a "cotton from flax." The name seems at first well chosen, but leads to the confusion of supposing that the flax changes its nature, and is converted into *cotton*. The process seems to be to thoroughly saturate the flax with carbonate of soda (or alkali), and then to decompose this, so that the gas at the period of evolution in the immediate neighbourhood of each filament adheres to some, and separating others almost instantaneously, converts tow and refuse of flax, &c., into a cotton-like substance; the fabric is "split" into more minute division and complete separation than can be obtained by any mechanical means. It has been proposed to treat the refuse of flax to be had at a cheap rate, and bleaching it to produce a cotton-like substance; but whether the cotton machinery can spin it without alteration,—whether it can take the place of cotton in all it properties,—and whether it can be obtained at a price that will enable it to be so used,—are questions for the practical man; and so far as statements go at present, the sanguine parties and the practical experimenters, have given results quite irreconcileable with each other. One party speaks of the economy of the process, while others speak of the great cost being per lb. more money for production that would purchase cotton in the market. These are questions for business calculations, but chemical principles point out that flax may be considered to be a bundle of colourless or white fibres or filaments, and these may by capillary forces be separated so far as to have but little strength when so reduced. Practice must find out the *bundle of fibres* most suited for particular purposes; and thus it may be expected that for coarse purposes, by simple mechanical means, the threads or bundles of fibres, with native gum, may be spun into coarse threads, and be woven into strong fabrics, while softer means, as pure water, heat, and pressure, separate and extend the fibres of the flaxen cylinders; and of course by chemical agency these may have capillary powers and individuality until they become fitted only for peculiar and very fine materials and purposes. Among the earliest communications made to the Society of Arts, is one from the Countess Moira, who fully developes the methods she employed, with the sort of cotton or wool she obtained, and clearly records the disappointment she experienced after her successful experiments, by the prejudice of the native workmen of Ireland, who positively refused to work at the new material. It is a most touching record of prejudice and habit, and shows that fortunate times are required to bring about the reception of new truths, or of old knowledge utterly disregarded.

The recent statements, however, and the hopes thus raised, have caused the attention of parties to be directed to the subject, and now substances are produced from flax that may be called "*flax-wool*," because intended to be used along with wool. Report speaks of its fineness, its length of staple, the glossy wear, and the properties it possesses, with appropriate machinery of mixing with wool, either to felt or to spin. Not only will new combinations of a *fancy* character be devised, but new materials be brought into use. Hair of some animals, too short to work, may be thus mixed with another material, with the flax chemically treated, and so most novel fabrics be tried. Thus 50 per cent. of flax-wool and 50 per cent. of rabbit down give one kind of material, and different proportions of flax and wool give other results. I have seen samples of various articles of dress in Ireland, and to this society are now exhibited woven fabrics of shawls and cloth, executed by the fancy trades of Yorkshire, that attest the skill of the mechanist and dyer to produce an adaptation of such very different materials in their natural origin. The raw materials of the English specimens of the manufactures are from Pocklington, while samples of the varieties of the flax plant and fabrics are contributed from Ireland, Yorkshire, and Nottinghamshire. Of the importance of the subject of flax there can be no doubt, whether we regard the condition of the people, or the changes now to be introduced in agriculture and manufactures, by skill and commerce.

Ireland, by situation, climate, and soil, by energy, by public societies, by grants, premiums, public meetings, institutions and literature, has raised itself from being an importing country into an exporting country. The whole area laid down for flax in 1852 is estimated at 136,000 acres sown with flax seed, and the entire supply for the United Kingdom would require the produce of 500,000 acres; and as to the value of crops thus brought from the land, it is stated on the competent authority of the accomplished writer of the articles "On the Flax Industry," published in the *Times*, October, 1852, "That we are contributing a sum of £4,000,000 annually to the farmers of other countries, for an article of produce especially our own, and which on all hands is acknowledged to be, under fair management, a paying crop."

Into these great financial questions I shall not go, but call attention to those points that may show the force of prejudice and determined opposition to improvement. We see the Hindoo *wasting the fibre*, and carefully collecting the grain; the Irishman heedless of the seed, and working only for the fibre, importing from other lands seed to replace that destroyed by waste at home; the Englishman, believing that the seed and plant alike exhaust the ground, and are too unprofitable to pay, while England gladly pays and freely imports from many lands the flax in fibres, the flax in *seed* for *sowing*, and for *oil*, and *cake*, as food to fatten cattle. The obscurities of simple processes, the tradition of ages, receive satisfactory explanations by the closest application of chemical talent, and happy suggestions are made to avoid nuisance and pestilence and utter uselessness and loss, and to convert the same into substances unexpectedly useful; into food taken with grateful relish, and with healthful and most profitable results. When we see chemistry thus aiding life, and capillary and chemical forces acting upon the delicate fibres, so as to render them mixable with other materials, blending so as to produce strength, novelty, and beauty, with the prospect of profit, I hope that the claims of science to advance business interests will be felt by all; while the early and experimental specimens of the manufactures will speak to those who are best able to understand the staple trades of this great town, and the value of meetings such as this Society purpose, when the men of science may appreciate the conditions of manufactures, and the energetic capitalist see the union that can alone accomplish required results,—the union of intelligent industry, capital, confidence, simple mechanism with cheap power, and chemical analysis guiding chemical affinities and results.

The researches of Sir Robert Kane and Dr. Hodges, and the labours of Mr. MacAdam, were dwelt upon; and the trade literature of flax in Ireland; acknowledgments were made also to Dr. Hodges, Mr. Denison, and Messrs. Marshall, for samples.

At the conclusion of the paper, a discussion took place, and many remarks were made by Mr. Ludolf, of Leeds and the East Riding; Mr. Huggon, Mr. Barrett, of Leeds; Mr. John Boyle, of Belfast, from Messrs. Lawson's, Leeds; Mr. Jackson, from Messrs. Denison's, Pocklington, and others belonging to Leeds and neighbouring towns.

In consequence of the length of these communications, and the discussions which followed, the paper "On Crystallization," by Mr. West, and that "On the Exhumation of Hippopotamic and Elephantoid Remains in the neighbourhood of Leeds," by Mr. Denny, announced for the meeting, were postponed.

Before the meeting adjourned, votes of thanks were proposed to the gentlemen who had communicated papers, and to his Worship for taking the chair, and carried unanimously.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FORTIETH MEETING, HELD IN THE GUILDHALL, DONCASTER, ON WEDNESDAY, AUG. 24TH, 1853.

EDWARD SCHOFIELD, Esq., M.D., in the chair.

The following gentlemen were proposed as Members of the Society:—

WM. BECKETT, Esq., M.P., of Kirkstall Grange.
PETER FAIRBAIRN, Esq., of Woodsley House.
JOHN MCLANDSBOROUGH, Esq., C.E., of Otley.
Rev. PHIPPS CHAMPNEYS, of Skellon, Doncaster.

The Chairman, after briefly addressing the Society, and announcing the subjects of the communications to be brought before the Meeting, called upon W. S. Ward, Esq., of Leeds, to read the first paper—

ON A NEW THERMOSTAT FOR REGULATING VENTILATION.

BY W. S. WARD, ESQ., LEEDS.

Mr. Ward said—Having been engaged in horticultural pursuits, he had found that it was desirable to have some instrument for regulating the ventilation and temperature of hothouses, without requiring the close attention of the gardener. He then described the invention which he calls a Thermostat, and which consists of metallic vessels, in which the vapour of a volatile liquid is used to give motive power for opening or shutting ventilators, or dampers, or regulating the flow of hot or cold water, or similar applications for regulation of temperatures. The vapour of æther has been used for such purposes when confined in tubes by mercury, but in such apparatus the amount of power to be obtained is much limited by the weight and consequent expense of mercury required. He makes use of vessels of thin metal, of which the ends or sides being discs of metal, are so thin and flexible as to be changeably either convex or concave, and in which the vapour of sulphuric æther (or of suitable volatile liquid), along with a portion of such liquid, is enclosed; the discs or ends of such vessels acting as diaphragms, separating the vapour from the external atmosphere, will, at temperatures under the boiling point of the fluid employed, be pressed inwards by the atmosphere, but with a pressure varying according to the temperature. He therefore attaches a counterpoise of sufficient weight partially to counteract the pressure of the atmosphere, so that the differential pressure of the æthereal vapour above or below the degree at which the pressure is counterbalanced, gives motive power. And as the extent of motion from each of such moveable surfaces is very slight, he combines several of such vessels together, so as to have several moveable ends or discs; and as there is a peculiar action when a weight is employed to extend such discs, it is advisable to use a combination of two pulleys, placed eccentrically on the same axis, so that a descending weight may operate in a rapidly increasing ratio. Motion being thus produced, it is obvious that if the Thermostat be geared to the ventilators of hothouses or of buildings, and to pipes supplying hot or cold water, or to dampers of furnaces, and to numerous similar purposes, by a sufficient size and number of flexible surfaces, any reasonably required power and extent of motion may be obtained.

Mr. Ward then exhibited the apparatus, of which a drawing is annexed.

Figure 1 represents a section, and figure 2 a front view of an apparatus. The same letters indicate the like parts; A A A A A A represent a series of thin vessels, by preference of copper, tinned, in the form of very short cylinders having the ends slightly raised or dished. These vessels are independent of each other, being connected by socket joints and pins, are suspended from a frame, and have a weight attached through the medium of pulleys. Each of the vessels contains a portion of sulphuric æther, and after the æther has been boiled therein so as to expel the atmospheric air, the aperture is sealed with solder; such sealing is easily effected, if two apertures be made in any part of the apparatus, one about $\frac{1}{20}$ of an inch in diameter, and the other about $\frac{1}{100}$ of an inch, and the larger one first soldered, the soldering being effected just when the æther has ceased to boil. In such apparatus the boxes are about eight inches diameter, and six in number, so that twelve flexible surfaces are combined; the thickness of the copper is such that a square foot weighs about one pound. The weight may be varied from about five to fifty pounds, according to the temperature which the apparatus is intended to regulate. The proportions of the eccentric pulleys used are such, that when the weight is raised the tension upon the series of vessels is a little increased by leverage; but when the weight has descended so as to turn the pulley about half round, on account of the varying leverage, the tension on the series of vessels becomes about five times that amount, but this will require adjustment by trial with each apparatus. When properly adjusted, the weights should have equal tension on the vessels throughout the half turn of the pulleys, as in the fusee of a watch; and the eccentrics are made with slots, so that they may be adjusted on the axis.

Mr. Ward has found sulphuric æther the most suitable for temperatures ranging from 40° to 90° of

Fahrenheit's thermometer. Alcohol, with its vapour, for temperatures from about 90° to 180°. Water, with its vapour, for temperatures from about 180° to 212°; other fluids may, however, be used. When the Thermostat is fixed in such structures as hothouses, he prefers that it should be shaded from the direct rays of the sun. He also exhibited the following table of the tension of æther vapour at various temperatures, and of the pressure of the atmosphere in pounds, on each acting square inch of the apparatus :—

Temperature.	Tension of vapour in inches of Mercury.	Pressure of Atmosphere on apparatus in lbs.
34°	6.2	11.9
44°	8.14	10.93
54°	10.3	9.85
64°	13.	8.5
74°	16.1	6.95
84°	20.	5.
94°	24.7	2.65
104°	30.	0.

Mr. Pearsall, of Leeds, said a few words on the subject, and referred to the vast importance of such an invention as that which had just been described, and especially to its introduction into hospitals, and for a variety of useful purposes. It was capable of very important results.

ON THE ORIGIN OF SLATY CLEAVAGE. BY H. C. SORBY, ESQ. F.G.S., OF SHEFFIELD.

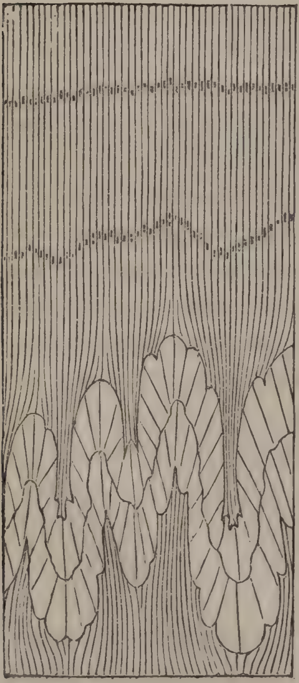
Before describing the theory I have propounded to account for what is called "slaty cleavage," it will probably be the best for me to explain briefly the nature of this structure and of the problem to be solved. Most stratified rocks can be split with more or less facility in the plane of their bedding, but in certain districts, greatly disturbed by elevatory forces, besides this line of weakness, there occurs another, only remotely connected with the bedding, and often so much more decided, that they were at first confounded, and the stratification overlooked, until the true nature of cleavage was pointed out by Professor Sedgwick. In most districts possessing cleavage, the stratified beds are much contorted, and dip at all angles, whilst the cleavage passes through them with more or less regularity, in some cases quite independent of the bedding. I should occupy far too much time if I were to describe one-half of the facts connected with this very extensive subject, and shall therefore confine myself to but few.

It is most important to bear in mind that cleavage is quite distinct from jointed structure. Joints are mere cracks and fractures, whereas cleavage is a structural weakness affecting the whole mass of rock. The question, therefore, is, how this structural weakness was developed? Mr. Fox, of Cornwall, found that a kind of laminated structure was produced by passing an electric current through clay, and Hunt has since repeated, confirmed, and extended his observations. I, however, think this electrical theory is quite inadequate to explain the phenomena, which in my opinion are chiefly, if not entirely, due to a mechanical cause.

It is now several years since a very distinct relation was observed to exist between the direction of cleavage and the axis of elevation of the cleaved district; and several observers, chiefly Professors Phillips and Sharpe, have shown that the organic remains found in slate rocks indicate a considerable change in their dimensions, being so altered in form as to shew that they had been greatly compressed in a line perpendicular to the plane of cleavage. The latter geologist, in memoirs communicated to the Geological Society, strongly advocated the supposition of the cleavage being produced by this pressure.

Having for some time been occupied with studying the microscopical structure of rocks, and being persuaded that cleavage must be due to some peculiarity in the arrangement of the particles, I applied this method of research to slaty rocks, by preparing sections of such extreme thinness as to admit of being examined with very high powers, and have been thus led to form a theory materially different from any yet propounded, which will, I think, not only explain the structure, but every fact I have yet met with. As already mentioned, the organic remains found in these rocks have been observed to be so changed in their form as to indicate a compression of the rock in a line perpendicular to the plane of cleavage, and an elongation in the line of dip. What I have seen enables me to confirm this fact; and I have also myself observed several others, most clearly proving that this change of dimensions has occurred.

Vertical Section seen in the Cliffs near Ilfracombe, North Devon.
Scale, 1 *Inch to* 1 *Foot.*



Fine-grained, dark coloured, shaly slate; the bedding shewn by bands of coarser grain and lighter colour, which, in the upper part, are not contorted. The cleavage is well developed, and dips about 60° to S. by E.

Much contorted bed of coarser-grained light-coloured sandy slate, wish less perfect cleavage.

Fine-grained slate, as at the upper part.

Referring to the accompanying figure, it will be seen that the bed of sandstone has been contorted in just such a manner as if it had been compressed laterally, parts which must have been about thirty-eight inches apart when the bed was level, being now only nine. Just above and below this bed is fine-grained, dark-coloured, shaly slate, in which the bedding is shewn by bands of coarser grain and lighter colour, which are not continuous, but, as usual, broken up into spots, as seen in a section perpendicular to cleavage in the line of dip, but as bands in its plane. Near the greatly contorted bed these bands are also somewhat disturbed, but at a short distance, both above and below it, they are quite regular and not at all contorted. This interstratification of much contorted beds with regular, seen in slate rocks, has long been an unexplained difficulty, but I think it is readily accounted for by supposing that the contorted sandy bed could not give way and change its dimensions so much as the finer-grained slate above and below it. It is in my opinion analogous to what would occur if a strip of paper, for instance, was included in a mass of some soft plastic material, which would readily change its dimensions. If the whole was then compressed in the direction of the length of the strip of paper, it would be bent and puckered up into contortions, whilst the plastic material would readily change its dimensions without such being the case; and the difference in distance of the ends of the paper, as measured in a direct line, or along it, would indicate the change in dimensions of the plastic material. It will here be observed that the cleavage in the fine-grained slate is perpendicular to the line of pressure, as indicated by these facts. Moreover, if the contorted bed be examined, it will be seen to have had its dimensions altered in different parts by this pressure. Of course it would originally be of nearly uniform thickness, but now it is about one quarter as thick in those parts lying nearly in the line of cleavage, as in those perpendicular to it. I have observed similar facts in all the contortions in slate rocks I have yet seen. It will also be remarked that the cleavage lies in the line of greatest thickness of the beds. I have found that this is the case in every instance, whatever be its inclination, and that, though it may vary as much as a right angle in contortions at no great distance from one another, yet there the cleavage does not pass evenly through them, as would most probably be the case if it was not due to a mechanical cause, but coincides with the line of maximum elongation. The fan-shaped arrangement of the cleavage in the contorted bed is what occurs in such cases in coarse-grained slates, but in fine-grained it is very slight, or even absent.

These changes of dimension appear to result both from the absolute compression of the rock by forcing more closely together the ultimate particles, and from an elongation in the line of dip, that is to say, upwards, where nothing but the weight of the mass opposed it. This is indeed rendered almost certain by an examination of the green spots so often seen in some slates. I am persuaded that they have been a kind of concretion, formed round bodies lying in the plane of bedding: and in rocks not having cleavage, such spots are spherical or somewhat elongated in the plane of bedding. In slate rocks, however, they have been greatly changed in their form and dimensions. When seen in a section perpendicular to cleavage in the line of dip, they are much longer in the direction of cleavage than perpendicular to it, the mean of very numerous measurements of such symmetrical ones as must have resulted from spots originally nearly spherical, in the slate of Penrhyn and Llanberis, shewing that the proportion was as 6 : 1. In the plane of cleavage they are seen to be elongated in the line of dip, the mean proportion between the length in that direction and that of strike, in the above named localities, being 1.6 : 1. Now if they had been originally spherical, and there had not been any absolute condensation, the ratio in the plane perpendicular to cleavage in the line of dip, calculated from that in the plane of cleavage, should have been as its square, viz., 2.56 : 1, instead of 6 : 1, and therefore there must have been an absolute compression from 100 to about 43, or, considering the nature of the probable errors, to about one-half of the original volume; and the close packing of the particles, as seen in thin sections, agrees well with this supposition.

I have found in some slate rocks rounded grains of mica, which have been broken up in such a manner as to indicate the same kind of change of dimension. But not to occupy too much time, I may state my firm conviction that there is abundance of facts to prove that slate rocks have undergone a very considerable change of dimensions, to which the cleavage is distinctly related, having been greatly compressed in a line perpendicular to its plane, and elongated in that of its dip.

The power most generally useful in examining slate rocks is about 400 linear, but higher and lower are of course valuable for particular purposes. It is almost indispensable to use a polarizing microscope, and there should be such contrivances as to give a good bright polarised light with high powers. The physical structure and optical properties of the minerals found in them are such, that they can be identified with great certainty, when in grains of even less than $\frac{1}{1000}$th of an inch in diameter.

Some slate rocks, as, for instance, the pencil slate of Shap, consist almost entirely of rounded grains and minute flakes and granules of mica, varying from about $\frac{1}{100}$th to $\frac{1}{10,000}$th of an inch in diameter, but chiefly under $\frac{1}{1000}$th. I do not believe that this is in the least due to metamorphism, but has been a deposit of micaceous mud, for the rounded grains have every character of being water-worn; and in the limestone of Rhiwlas, near Bala, which consists almost entirely of such grains and flakes of mica, and fragments of encrinites, their organic structure is as perfect (or even more so) as in any limestone with which I am acquainted, though I have prepared and examined thin sections of several hundred specimens of every geological period; and so much so, that any material amount of metamorphism is wholly out of question. When deposits of decomposed felspar have been acted on by great heat, they are, as it were, baked into a natural porcelain, but no such grains of mica are formed. Usually, besides mica, there is found in good roofing slate, like that at Penrhyn, a certain proportion of decomposed felspar, a few minute grains of quartz sand, and granules of phosphate of iron. The red tint is produced by the presence of very numerous minute crystals of peroxide of iron, and the dark by those of pyrites. From such slate there is every gradation to those containing little or no mica, but made up of more or less fine quartz sand, and decomposed felspar, in very variable proportions; but these have only an imperfect cleavage. Other slates, as is well known, contain much chlorite and other minerals. On the present occasion I shall chiefly confine myself to the consideration of such slate as has a perfect cleavage.

If a thin section of a rock not having cleavage be examined, which has a similar mineral composition to those which, when having it, form good slates, it will be seen that the arrangement of the particles is very different. For instance, the well known Water-of-Ayr stone has no cleavage, but shows more or less of bedding. It consists of mica and a very few grains of quartz sand, imbedded in a large proportion of decomposed felspar; the peroxide of iron being collected to certain centres, and having the characters of peroxidised pyrites. The flakes of mica do not lie in the plane of bedding, but are inclined tolerably evenly at all angles, so that there is no definite line of structural weakness, independent of that due to bedding, which results chiefly from alternations of layers of somewhat different composition, and not from the arrangement of the ultimate particles. This is, however, totally different in a rock of similar composition having cleavage. If a section be examined cut perpendicular to cleavage, in the line of its dip, it will be seen that though some of the minute flakes of mica lie perpendicular to the cleavage, or at high angles to it, by far the larger part are inclined at low angles, so that the majority lie within 20° on each side of it. In fact they are most numerous nearly in the plane of cleavage, and gradually but rapidly diminish in quantity in passing to higher angles, so that there are twenty times as many nearly in the plane of cleavage as at 45° to it, and very few at 90°. Where a section is examined cut perpendicular to cleavage in the line of the strike, it is seen that the arrangement is similar, but there is not nearly so rapid a diminution of the numbers in passing from the line of cleavage, so that there are comparatively several times as many more inclined at about 45° to it, as when the section is in the line of dip, and those at still higher angles are also much more numerous. In a section in the plane of cleavage, but few flakes are cut through so as to have a greatly unequiaxed form; but they are similarly arranged with respect to the line of dip, though not in so marked a manner. It is not merely the larger flakes of mica that are thus arranged, but the whole of those unequiaxed particles which existed in the rock before the cleavage was developed.

When a cleavage crack in the thin sections is examined, it is clearly seen that the cleavage is due to the above-described arrangement of the particles, which it follows most perfectly, not passing straight forwards, but turning about according to the manner in which the ultimate particles lie in every part. It therefore appears that the fissile character of slate is due to a line of structural weakness, brought about by the manner of arrangement of the ultimate unequiaxed particles. The natural cleavage cracks, of course, bear the same relation to this arrangement as those so often seen in many crystalline bodies do to that of their ultimate atoms. They appear, in general, to have been mainly due to meteoric agencies; their position having been determined by the structural weakness. In accounting, then, for so-called slaty cleavage, it is only requisite to shew how such particles could have had their position so changed that their arrangement should be altered from that found in rocks not having cleavage, to that in those having it; which explanation must, of course, be such as would agree with every other fact connected with the subject.

Now I trust I have already shewn that there is abundance of evidence to prove that rocks having slaty cleavage have been greatly compressed in a line perpendicular to cleavage, and elongated to a certain extent in the line of its dip. Taking for the amount of these changes those I have already mentioned for the slate of Penrhyn and Llanberis, it is easy to calculate mathematically what would be the arrangement of the unequiaxed particles in such a rock as Water-of-Ayr stone, if its dimensions were so changed. Supposing that A = the angle of inclination of the longer axis of any unequiaxed particle to the line along which the maximum elongation would occur, and that a = this angle after it had taken place, we should have, perpendicular to cleavage in the line of dip, $\tan a = \frac{\tan A}{6}$; in that of strike $\tan a = \frac{\tan A}{3.75}$; and, in the plane of cleavage, $\tan a = \frac{\tan A}{1.6}$.
From these relations it necessarily follows that the particles

would then be arranged in precisely such a manner as is seen to be the case in such a rock having cleavage, the agreement being most perfect in every particular, both in kind and amount, as seen in sections cut in each direction.

Though such calculations may be fully relied on, yet, to satisfy myself that they were correct, I have tested them by actual experiment. Having mixed some scales of oxide of iron with soft pipe-clay, in such a manner that they would be inclined evenly in all directions, like the flakes of mica in Water-of-Ayr stone, I changed its dimensions artificially to a similar extent to what has occurred in slate rocks. Having then dried and baked it, I rubbed it to a perfectly flat surface, in a direction perpendicular to pressure, and in the line of elongation which would correspond to that of dip of cleavage, and also, as it were, in its strike, and in the plane of cleavage. The particles were then seen to have become arranged in precisely the same manner as theory indicates that they would, and as is the case in natural slate; so much so, that, so far as their arrangement is concerned, a drawing of one could not be distinguished from that of the other. Moreover, it then admitted of easy fracture into thin flat pieces in the plane corresponding to the cleavage of slate, whereas it could not in that perpendicular to it. Even in clay, which has but few very unequiaxed particles, a most distinct lamination is produced by changing its dimensions as described above, but it would not cleave perfectly, no more than will natural slate of similar mineral composition; and, moreover, one cannot obtain their firm, uniform structure.

It is a fact well worthy of remark, that in well cleaved slates, on each side of the larger rounded grains of mica, in the line of cleavage, the particles are arranged evenly at all angles, over small triangular spaces, having their bases towards the grain. This is just the part which would be protected from change of dimensions by its presence; and this fact is therefore very good evidence of the slate having had originally such a structure as would be changed into its present form, if its dimensions had been altered in the manner and to the extent indicated by the breaking up of other rounded grains of mica seen in the same thin section.

What I therefore contend is, that there is abundance of proof that slate rocks have suffered such a change of dimensions as would necessarily alter the arrangement of their ultimate particles from what is found in rocks not having cleavage, to that in those which have, and hence develop a line of structural weakness in the direction in which it really does occur.

Some slates have a very poor cleavage, although their mineral composition is similar to that of such as often have a most perfect one. In these the green spots indicate a comparatively small change of dimensions; whence it would appear that the perfection of cleavage depends both upon the ultimate mineral composition, and the amount of change of dimensions of the rock.

If the direction of the cleavage be examined in the various parts of the section given at page 302, I cannot conceive how they could possibly be explained except by such a theory as I am now advocating. In the coarser-grained sandy bed it coincides with the axes of all the contortions, and is in the line of greatest elongation of the thickness of the bed, and perpendicular to the line of pressure. It is arranged in fan-shape in all the contortions, as though they had been squeezed together after the sandy bed had suffered as much compression as it admitted of. The cleavage in the fine-grained beds at some distance from the contorted one, is perpendicular to the line of squeezing, as indicated by its puckering up, and the increase and diminution of its thickness in passing round the contortions; but when approaching their rounded ends, though the cleavage passes straight forward in the line of their axes, it spreads out on each side, and curves down into the sharp-ended spaces between them, in just such a manner as would necessarily occur if the coarser-grained bed had been less compressed than the other. It would also follow that the above-mentioned fan-shaped arrangement would be of greatest amount in such beds as offered much resistance to change of dimensions, whereas in fine-cleaved slates it would be very small, or even not occur at all; and such is the fact observed in the rocks themselves. It would also necessarily follow from this theory, that the strike of the cleavage would usually coincide with the general strike of the beds, and be parallel to the main axis of elevation of the district, as has been found to be so commonly the case. The dip of the cleavage planes over any extensive district would likewise be as has been observed; and it is easy to explain why it should differ in contiguous interstratified beds of different nature, and why their junctions should often be irregularly wrinkled. There are also many other facts connected with the subject which may thus be readily explained, but it would occupy too much time to describe them.

Perhaps it may be said, How is it possible that hard rocks could have had their dimensions changed to the extent described? To this I would reply, If the rocks be examined, it will be seen that it really has occurred; and I would suggest that solidity is but a comparative property, and that the intensity of the forces in action during the elevation of a range of mountains could gradually change the dimensions of rocks; for it is well known that many hard and brittle substances will admit of such movements, as, for instance, the ice of glaciers, and hard and brittle pitch.

I would now ask, How is it possible to reconcile all the mechanical facts I have described, which are so clearly related to the cleavage, with the supposition of its being due to electrical action, or any other non-mechanical cause? If I be not greatly deceived, they all form a most complete whole, if viewed in the light I have placed them in; whereas, so far as I can see, they are quite incomprehensible on the latter supposition; nor, so far as I can learn, have its most zealous supporters ever given any satisfactory reason for the manner of distribution of the cleavage planes, even assuming them to be as regular and uniform as some authors appear to describe them. Mr. Sharpe's theory, of course, only differs from mine in his assuming that the particles have been really *compressed;* whereas I am persuaded that in general they have only suffered a *change of position.* This, however, no doubt resulted from the different method of research I have adopted. It would, however, cause me to extend this communication to too great a length to enter fully into all these questions, or describe many other facts I have observed connected with the subject. My object, in the present paper, is to give a rough outline of my observations and theories; and though it is already rather long, yet I fear many points will have been far from understood, for to explain them all would require much detail.

A DESCRIPTION OF THE HYDROSTATIC MACHINERY AT GREAT GRIMSBY DOCKS. BY GEORGE BROADRICK, ESQ., C.E., OF HAMPHALL STUBBS, DONCASTER.

The class of machines under notice in the present paper presents few varieties of principle or construction, and previous to the invention of Mr. Armstrong's machinery, the only examples of it were to be found in the hydrostatic press of Mr. Bramah, and the water-pressure engine, the latter of which had come into use to a very limited extent.

The machinery, of which such excellent examples are now to be found at Grimsby and many other places, was first introduced at Newcastle in 1845, and is patented by Mr. W. G. Armstrong, C.E., of the Elswick Engine Works, Newcastle on-Tyne. It has for its objects the transmission of force from any central prime-mover, as a steam-engine or water-wheel, to any distance, in the most convenient manner; the application of this force to work different kinds of machines at any point or points on its passage; and also the multiplication of the force by machinery constructed upon hydrostatic principles, in the manner formerly effected by trains of wheelwork, or by pulleys, &c. The properties and principles of liquids employed in this machinery are the same as those taken advantage of in the hydrostatic press, being chiefly incompressibility and equality of pressure in every direction, with the resulting law, that the aggregate pressure upon any surface is as the size of that surface.

Before proceeding to describe the machinery at Grimsby, in which no rotatory movement is required, I may mention that the pressure of water has been applied with great success by Mr. Armstrong to the production of a continuous rotatory motion, and that he has thereby put us in possession of a machine capable of being used with nearly the economy of a steam-engine, in situations where the latter could not be used. This is the case in the galleries of mines, and similar confined and inconvenient situations. The great objection to all the older machines of this kind, namely, the violent concussions to which they were subjected at every stroke, has been entirely obviated in those erected by Mr. Armstrong. The machinery I am about to describe consists essentially of three parts—the prime-mover, which generates the force, the reservoir of that force, and the means by which the force is multiplied and applied to the performance of the required work. The prime-mover is usually a steam-engine, furnished with force pumps, which supply the water to the reservoir of the force, which, from the nature of its action, has been termed the "accumulator." Its object is to act as a magazine for so much of the force of the engine as is given out during the time when the supply exceeds the demand for it, as when a part of the machinery in connection with the accumulator is at rest. This, it is obvious, must very frequently be the case where that machinery consists of cranes or similar appliances. The accumulator varies in form, according to the nature of the work to be performed by it; when it is probable that the whole of the machinery will be at work for the greater part of the day—as, for instance, in a set of cranes attached to a bustling dock establishment—the engine is of a sufficient size to supply the water as fast, or nearly so, as it may be required. If, however, there are portions of the machinery which are at rest the greater part of the day, as in the case of the dock-gate apparatus at Grimsby, the engine is of the size requisite to maintain in action only that portion of the machinery which is likely to be very frequently in motion, while the remainder can be worked from the accumulator when necessary. In the former case, the accumulator consists of a strong vertical cylinder, truly turned on the outside, over which is fitted, by means of a stuffing-box, a second and inverted cylinder, which is loaded with weights of iron or masonry to the required pressure per square inch. This cylinder, with its load, is supported and guided by means of a suitable framing. The force-pipes of the pumps being in immediate connexion with this apparatus, supposing no machinery at work, the outer cylinder will be driven upwards at every stroke of the engine, until it reaches the top of the framing, when a safety-valve opens and permits the escape of the water subsequently introduced. The hydrostatic machinery receives its supply from this accumulator by means of a main carried underground in the ordinary manner. In the second case mentioned above, viz., when very large demands are likely to be occasionally made on the accumulator, it takes the form of a reservoir of sufficient size, placed at such an elevation as to give the required pressure.

The principal working parts of the hydrostatic crane may be briefly described in a sufficiently clear manner, without the help of a diagram. They are required to effect the following objects:—First, to hoist the load to a certain distance; secondly, to give it a lateral motion, usually performed in a circular direction; and thirdly, the lowering or "over-hauling" of the chain with or without the load. The first movement, or the hoisting of the load, is effected by means of a ram or plunger working water-tight in a cylinder, fixed in any convenient position, which carries at its exposed end one or more pulleys, over which the crane-chain passes. One end of this chain is shackled to the cylinder, while the other is furnished with the usual means of attaching the load. The effect of a stroke of the plunger is to shorten the crane-chain by twice the length of the stroke, or by more, according to the number of pulleys—each pulley shortening the chain twice the length of the stroke. Hence, with three pulleys, and a plunger having a stroke of 10 feet, the chain would be shortened 60 feet, or the load attached to the end of it would be raised 60 feet. In this case, owing to the mechanical disadvantage at which the ram acts, the weight of the load raised must be less than one-sixth of the stress applied to the plunger, or the force to be applied must be more than six times as great as the weight of the load to be raised. This multiplication of force, however, is readily attained by increasing the area of the end of the plunger, at a corresponding expense of water and engine-power. The lateral motion of the load is effected by swinging the crane round, as in the ordinary manual-power machine. This is accomplished by means of two other hydrostatic cylinders, fixed one on each side of the centre of motion of the crane-frame. The rams of these cylinders likewise carry pulleys, which act upon a chain, one end of which is fastened to each cylinder, in such a manner that as one ram moves out of its cylinder and shortens its chain, the other enters its cylinder and gives out an equal length, so as to produce a movement of the chain in either direction, according as one or other ram is exposed to the pressure of the water, while the opposite one is relieved from it. The motion of the chain is communicated to the crane-frame by a pulley fixed upon the latter, into which the links of the chain are made to fit. The crane-chain is overhauled by means of a fourth hydrostatic cylinder of small diameter, but having its stroke equal to that of the hoisting-ram. This cylinder contains a ram which is always exposed to the pressure, and which acts in a direction exactly opposite to that of the hoisting-ram, the latter being made of a sufficient size to overcome the reaction of the over-hauling ram, as well as friction and the weight of the load. When the load has been hoisted up, and is to be lowered again, or when the chain is to be returned after delivering its load, all that is necessary is to cut off the pressure from the hoisting cylinder, and to provide an escape from it. This allows of the immediate action of the over-hauling ram, which drives the hoisting-ram back into the cylinder, and thus returns the crane-chain to its original position. It is obvious that the load can be maintained suspended at any height when convenient to do so, by merely cutting off the exhaust of the hoisting-cylinder.

Several ingenious contrivances are applied for removing any portions of rust, &c., from the water, before it is admitted to the valves or cylinders; for preventing the chain of the turning-barrels from falling off the pulleys, in case of the crane being turned any distance by hand; and for other purposes. The framing of the cranes at Grimsby is somewhat novel in construction, the strut of the jib being in two parts, forming an angle with each other, whereby great headway is allowed for the piling up of goods. These cranes are worked with ease by one boy, who performs all their evolutions with the greatest rapidity and certainty, by two handles governing the valves of the hoisting and turning cylinders. The machinery is generally concealed under the pavement of the wharves, or in some other convenient locality. When it is probable that the loads to be raised by the hydrostatic crane will vary greatly in weight, three or more hoisting-barrels are applied, the rams of which can be made to act in groups either of a single one, or more than one, so as to effect a saving of water when a light load is to be raised.

The system of hydrostatic machinery at Great Grimsby Docks consists of three classes of cranes; one class for the purpose of loading or unloading ships, another for loading and unloading waggons, and a third class is for the service of the warehouses; they vary in power from one to three tons. In addition to these cranes, there is an apparatus on a large scale for working the gates of the locks, and also for conveying persons to the top of the accumulator tower. The doors of the sluices by which the locks are filled and emptied, and the mud scoured away from the landing-places and dock-entrances, are also raised and lowered by hydrostatic pressure, which is further applied to facilitate the weighing of goods in the trans-ship sheds, by preventing the swing of the scales, and rendering the placing of the goods in them more easy. The machinery by which the dock gates—twelve in number, six of them spanning a distance of 70 feet—are manœuvred, is arranged as follows:—In the proper positions, and concealed under the pavement of the wharves, are fixed three large hydrostatic cylinders, furnished with pistons, and piston-rods passing completely through them. The piston-rod of each cylinder carries a pulley at each end, working in a carriage traversing suitable guides; each of these pulleys carries a chain, secured at one end to the brickwork, and carrying at its other a second pulley, over which a second chain passes, the pulley traversing similar guides to the first. The effect of a stroke of the piston is to produce a shortening of one of the last-mentioned chains to the extent of four times the length of the stroke, while the corresponding chain at the opposite end is lengthened by an equal quantity. These two chains are connected together by a line of rods lying in a groove under the pavement, and by means of chains passing round large pulleys at each end of the locks, so that any point in the line of rods and chains traverses in either direction a distance of four times the length of the stroke of the cylinders. This motion is communicated by means of a toothed wheel to each of the crabs which wind up the chains attached to the gates, and thus opens or closes them. One boy can manœuvre each cylinder, by means of levers governing the inlet and exhaust valves, and the gates can be opened or closed in the space of about two minutes on an average. All the above machinery lies beneath the pavement, and no part of it, except the crabs, occupies any space on the quays. The shuttles of the sluices mentioned above can be raised or lowered with the greatest facility by means of a hydrostratic cylinder fixed vertically in a well above them, to the piston-rod of which the shuttle is attached. The accumulator for working the above system of machinery consists of a stand-pipe, forming a continuation of the main from the engine, which rises to the height of nearly 200 feet, and is surmounted by a large iron tank. This stand-pipe and tank are supported upon a lofty and handsome brick tower, whose total height from the pavement of the wharf is 300 feet, it being about 28 feet square at the level of the pavement, and having a slight taper. The style of architecture adopted in this tower was suggested by that of the ancient fortresses of Lombardy; and its general appearance, with the extraordinary nature of its site, upon a deep bed of mud, at some distance from the high-water line of the Humber, combine to render it an interesting example of artistic and constructive genius. A fine view is obtained from the exterior gallery inclosing the tank, to which access can be readily had by means of a hoist or cage carrying five persons, worked by hydrostatic pressure, upon principles exactly similar to those of the Dock-gate machinery.

At the Old Dock, at Grimsby, a hydrostatic coal-drop has been erected, for the purpose of accommodating the mineral traffic which it was expected would pass along the line of the Manchester, Sheffield, and Lincolnshire Railway. It is worked from a weighted accumulator, and the hydrostatic power is applied to raise the loaded waggons from the railway to a sufficient height to clear the ship's side, and then to lower them to the deck, rehoist them, and replace them, empty, upon a separate line of rails. By this machine, minerals can be loaded with extraordinary speed, and with much less chance of breakage than when loaded by the spout. About twelve men are required to maintain this machinery in complete action, including the attendance upon the engine, but not including those required to stow the hold of the ship. It is capable of shipping 500 tons of coal in one day of ten hours, supposing the hold can be stowed with sufficient rapidity.

Besides the machinery recently completed at Great Grimsby, Mr. Armstrong is erecting cranes, dock-gate machinery, &c., at the following places, viz.:—the docks at Liverpool, Garston, Birkenhead, and Blackwall; also at the goods stations, in London, of the North-Western, Great Western, and Great Northern Railways; at the Crystal Palace, at Plymouth, and many other places.

The practical advantages to be derived from the use of the hydrostatic crane, are:—

1. The great economy of the power employed, which, it must be remembered, is *steam power*, the water being merely the vehicle by which the power of the engine is transmitted.

2. The applicability by this means of steam power to *small* cranes.

3. The facilities it presents for working a whole system of machinery, however widely scattered the different machines composing that system may be, from one engine in any convenient locality.

4. The small amount of *room* upon wharves taken up by hydrostatic cranes.

5. The great speed at which such cranes can be worked with small loads, a speed utterly unattainable by the manual crane.

From some experiments I made upon the cranes at Grimsby, I believe that in the case of any article which can be cleared from a ship's hold with sufficient rapidity, 500 tons per day of ten hours might be discharged, at a cost of one-third of that doing the same amount of work by the manual-power crane. In one establishment, indeed, the cost was reduced from 3d. to $1\frac{1}{4}$d. per ton by the use of the hydrostatic crane. Cranes are, in fact, now so complete, that little more improvement *need* be made in the rapidity of their action, until some methods are found out whereby the loading and unloading of vessels and other vehicles can be facilitated; as, when the articles are bulky or very heavy, even the manual crane remains idle for a considerable part of the time occupied in loading or unloading the cargo.

Hydrostatic machinery can be easily worked from the public water supply, if the pressure be sufficient. Its use is rapidly extending; it has been applied to the purposes of riveting, moving swing-bridges, turntables, and railwaytraversers, and the inventor even proposes to apply it to the performance of various kinds of work on board ships.

In reply to some questions by Mr. Liddle, of Lindholme, Mr. Broadrick said the hydrostatic crane was no more than the multiplying power of the engine.

Mr. Liddle said he thought that it might be made available, and would save much wear and tear of engines, on the works on the moors.

Mr. Broadrick said in that case it might be useful, because when the engine was not at work they might be filling the accumulator. They would in that case diminish the first cost of the engine, but they would have the accumulator to pay for; and although that was a simple thing in itself, yet it was not economical unless there was a large use of cranes. It would reduce the cost of cranage in some instances to one-half.

ON THE DISCOVERY OF HIPPOPOTAMIC AND OTHER REMAINS IN THE NEIGHBOURHOOD OF LEEDS. BY MR. H. DENNY, A.L.S., &C., LEEDS.

The superficial deposits which are so prominent in every quarter of the globe,—on the vast plains of South America, the swamps of North America, the flats and gorges of New Zealand and Australia, the ridges of the Himalayas, the shores of Siberia, the Steppes of Russia, and, lastly, on extensive districts in the British Isles,—must of necessity be invested with great interest, from the circumstance that such accumulations are the relics of the last physical changes which have taken place on the surface of the earth, and are, therefore, (geologically speaking,) of comparatively modern date, and, in some instances, probably, approaching to, if not during, historic times. These accumulations, known as beds of gravel, boulder clay, &c., are of varying character and nature, and also derived from different sources. They are, further, either extensive in their distribution, or limited and local.

The Rev. Wm. Thorp, in an able paper read before this Society, has demonstrated four such gravel beds as occurring in Yorkshire, of different geological ages and derived from different sources, each possessing peculiar and well marked characters. The *first* of these, which covers vast districts in other counties, and is known as the Great Northern Drift, has transported boulders of rocks from Cumberland and Westmoreland for 110 miles, over the plains of York, from the Tees to the Humber, and up to Flamborough Head. The *second* is a range of gravel which touches the former, and varies from one to two miles in breadth, and passes down the rivers Aire and Calder, from Leeds by Ferrybridge, to Goole, consisting of pebbles derived from an entirely different series of rocks,—those of the coal formation, consisting of the carboniferous sandstone, and, occasionally, mountain and magnesian limestone, which proves the direction of the currents to have been from west to east. The *third* is a range which has an east and west course down the river Don, to the south bank of the Humber, the pebbles of which are also derived from the coal formation, but of the harder sandstone rocks of Rotherham, and the mountain limestone of Derbyshire. A *fourth* range of diluvium is that which extends from near Bawtry, to one of the highest points in Nottinghamshire, and is composed exclusively of magnesian limestone pebbles. Hence, while the former and most extensive, which consists of boulders of granite, &c., is supposed to have been the result of a great current from the north, these smaller, almost wholly composed of the rocks of the coal district or its neighbourhood, are conjectured to have been derived from the materials of the coal field by the waters which were driven eastward during the time of emergence, and down the lines of the valleys, as the Aire, Calder, Don, &c.

Now, from the distance of transport and overwhelming force of the former, the geological date of which is known, the remains of animals and plants might be transported into regions in which they were previously unknown, and there deposited beneath vast masses of gravel and other accumulations; but in the case of the latter, which are of limited extent, this could not occur, and we may trace an interesting distinction in the state of their organic remains, inasmuch as the animals appear to have been living in the districts at the period when they were inundated by the torrents of water, alluvial mud, and gravel, in which they are entombed, and this consequently proves the aboriginal character of the quadrupeds whose remains are now found in such situations, which generally follow the course of valleys, either excavated at the period by the force of the water, or the former beds of rivers since diverted. In instances where animals not natives are transported from remote districts, their bones are scattered, fragmentary, frequently water-worn, and associated with rocks from distant localities and of varying kinds; while in cases like these, of animals submerged in their native haunts, their remains are generally in close connexion, present a very recent and unbroken appearance, and have not those distant materials buried with them which serve the purpose of medals, if I may so speak, or references to the districts from whence they were derived.

From the summary just given, and from the circumstance that my communication owes its origin to a local deposit, it will readily be perceived that the one to which I have now to call your attention is the second enumerated by Mr. Thorp, which extends down the valleys of the Aire and Calder, and, consequently, passes though Leeds and the adjacent neighbourhood, on the S., S.W., and S.E., and whose materials have recently been so fully developed during the sewerage excavations through Kirkstall Road, Wellington Street, Wilson Street, and Hunslet Lane, on which line numerous boulders of grit stone occurred with the gravel. Here also the remains of various ruminant and pachydermous animals have been found at different periods, viz., in the last locality, several heads, horns, and bones of the Short-horned Ox; jaws, teeth, and bones of the Horse, Swine, and Goat, and a magnificent horn, three feet in length, the jaw, and metacarpal bones, of the Red Deer; the latter associated with large trunks of trees, upwards of 22 feet in length and 52 inches in circumference, which were at the depth of 20 feet from the surface. In excavating for the docks at Crown Point, the skull of the Red Deer was found 10 feet below the surface. At St. Peter's Hill and on Kirkstall Road, two horns and bones of the same animal, with hazel nuts and branches of trees, were also found 6 feet 6 inches below the surface. At the Monk Pits, when excavating for the Railway Station, numerous bones of the Short-horned Ox and Deer, human bones, and fragments of pottery, were exhumed 12 feet below the surface. In all the instances just named, the remains were in gravel, or, apparently, lacustrine deposits, and, therefore, comparatively recent, belonging to the Post-glacial period of Phillips, or that immediately succeeding the last subsidence of this portion of the British Isles,—when animals mostly resembling those of the present day were inhabitants of Yorkshire, such, for instance, as the Giant Deer, Red Deer, Fallow Deer, Short-horned Ox, Horse, Swine, Goat, &c.

At a period, however, antecedent to that just mentioned, the fauna of the Yorkshire hills and plains is generally supposed to have been of a totally different and more tropical character, viz.,—the Pre-glacial period, when Yorkshire was inhabited by the Lion, Tiger, Hyæna, Bear, Wolf, Elephant, Rhinoceros, Hippopotamus, Giant Deer, Urus, and also other animals similar to those of the present day.

An accidental, though highly interesting discovery, however, having been recently made in the neighbourhood of Leeds, which militates against the latter supposition, or, at least, that part of it which teaches that the larger pachyderms ceased to exist with the Pre-glacial period; and as the placing on record any fact regarding the discovery in a fresh locality of remains of the former inhabitants of this island is of great importance, either in confirmation of, or disproving the accuracy of existing theories, I am induced to occupy the attention of this Society for a few minutes, in order to lay before them a short notice of the exhumation of a considerable number of bones of the Great Northern Hippopotamus in the township of Wortley, and parish of Leeds. On the 3rd of April, last year (1852), as some workmen in the employ of the Messrs. Longley, of Leeds, were digging clay for the purpose of making bricks, they discovered, at the depth of 10 feet, in a dark blue sedimentary clay, almost approaching mud, several large bones, some of which attracting their attention more than the others, were brought to me, and, from the situation in which they were found, it was highly probable that the animals to which they belonged had lived and died in the immediate vicinity, and were subsequently drifted, together with fragments of trees, to the bottom or lower part of a swamp, for not only is this particular bed of clay confined to one portion of the field, but the whole series of beds of clay become much thicker as they approach this spot, thus clearly indicating it to have been lower than the remainder. I was much surprised in observing that, although the field is very limited in extent, the variation in the strata or deposits in those parts which can be observed is very considerable. Towards the S.E. no clay is found, the sandstone reaching the surface; but towards the centre, in a westerly direction, where the bones were deposited, in one section is a bed of clay from five to six feet thick; next a bed of grayish sand, of about two feet, which runs out a little further to the south-west to two inches in thickness; this is succeeded by a bed of yellow sand two feet thick; and fourthly, by another bed of white sand, in which are a vast number of boulders, perfectly rounded by attrition. These are, with few exceptions, all grit or sandstone, with an occasional fragment of limestone or chert. In another direction is a bed of dark red gravel; while in the particular spot where the Hippopotamic remains were deposited no sand or gravel appears, but a series of beds of clay, of variable quality, with occasionally large boulders, some of which contain impressions of Stigmaria, and fragments of trees, to the depth of ten feet, where it becomes valueless for the purpose of brickmaking, consisting of so large a proportion of sediment or mud, and is consequently not worked.

It is much to be regretted that the attention of the labourers was not earlier directed to the preservation of these interesting remains, of which a number had been neglected and destroyed before their curiosity was excited by the discovery of one of the massive thigh bones and the fore arm, whose unusual size, to use their own words, "made them think they could not be Christians' bones," and, therefore, to solve this important problem, they determined to bring them to the Philosophical Hall. Upon ascertaining their identity, I visited the field daily, and sometimes twice a day, and ascertained that two scapulæ, six molar teeth, three incisors, and various small bones, had been found and destroyed. I was also informed that in the adjoining brickfield, in the same bed of clay, several large bones had been found during the previous year. Having now stimulated the men by the promise of pecuniary reward to increased care and search, in the course of a few weeks I was in possession of the other femur, the right and left humerus, the left radius and ulna, two scapulæ, the tibia and fibula, the pelvis, three specimens of the astragalus, the right os-calcis, one carpal, and five entire meta-tarsal bones, a large portion of the cranium, and part of the lower jaw, with the two straight incisors, fragments of the upper and lower jaws, with the molar teeth, together with examples of nearly all the incisive and canine tusks and teeth, two cervical, seven dorsal, and nine lumber vertebræ, the sacrum, numerous fragments of ribs, and a large quantity of fractured bones from various parts of the skeleton.

From an examination of the teeth alone, thus obtained, without taking into account those which were destroyed, (of which fact I had undoubted evidence), I found that there had been two adult individuals,* one considerably larger than the other; but whether this difference in size was owing to age, or merely a sexual distinction, I am not aware, but I presume the latter is the cause, as we always find the males provided with defensive weapons of greater magnitude than the females. That both were adult I have no doubt, and one I believe to have been a very old animal, from the surface of the molar teeth being so much worn down, as well as the extremities of the great incisors. Besides these, I found fragments of canine teeth evidently belonging to a young animal, the extremities of which are perfectly smooth and pointed; also some meta-tarsal bones and vertebræ, of which the epiphyses had been separated and lost, and also a portion of a scapula was obtained, with the glenoid cavity, which, from its much smaller size, is indicative of its having belonged to a young individual.

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* Since this paper was read, a much larger example of the canine tusk has been found, belonging to a third and more aged individual, as also some other bones.

These bones were not, as is usually the case, dispersed and fractured, but confined to the limited space of a few yards; thus affording presumptive evidence that the animals had not been drifted from a distance in detached portions and separately embedded in the sedimentary deposit; for, on the contrary, I observed that the vertebral column of one individual extended in a line across the trench, the ribs appeared to have been *in situ*, the pelvic bones and head were contiguous, as well as some of the bones of the extremities, and from their position, I should conjecture the animal to have been lying upon its side. The bones of the feet are comparatively few, and the caudal vertebræ are entirely missing. This, however, may have arisen from their size not being sufficient to attract the attention of the workmen in the first instance; and subsequently, upon re-tempering the clay, only a few meta-tarsal bones have been detected, and some of these only within the last three weeks. When it is borne in mind, however, that nearly a year and a half has elapsed since the clay was first dug, and that it has since laid exposed in the brick-yard, it is only surprising that any of the bones have been preserved to this day, to attest the fact that the Hippopotamus was once an inhabitant of the valleys and plains of the West Riding of Yorkshire.

That the extinct Hippopotamus was equal, if not superior, in size to the species now inhabiting the rivers of Africa, is evident from a comparison of some of the bones and teeth in the two species. The great median incisor, or canine tusk, found at Wortley, measures 18 inches in length by 2¼ inches in breadth; and the straight incisor of the lower jaw, 12 inches by 1¾ inches; while the former tusk in a fine recent skull of a mature animal in the Museum of the Leeds Philosophical Society, measures only 15 inches in length. The extremities of the straight incisors are very peculiar in form in the fossil species, to which I do not find any allusion by Professor Owen, in his valuable History of British Fossil Mammalia.

Besides the Hippopotamic remains, I have discovered, amongst the numerous bones obtained from the brick-field at Wortley, the following belonging to the Elephant: The glenoid cavity of the scapula, portions of the femur and tibia; the articular surfaces of the humerus and left femur; left os-calcis; part of the ischium, with the acetabulum, and fragments of the tusks; also a large portion of the jaw with teeth; a molar tooth, and fragments of the radius, &c., belonging to some large ruminant, which I believe to be the Urus, *Bos primigenius*. It is somewhat singular, however, that there is a marked difference in the state of perfection and the number of the bones of these different animals. For, while those of the Hippopotamus are the most perfect as well as most numerous, and lie in such immediate proximity as to warrant the supposition that the animals had lived on the spot or in its immediate vicinity, those of the Elephant are few, from different parts of the body, much fractured, and apparently weatherworn; and those again of the Urus still fewer in number, more broken, and in some parts rounded as if by attrition; from which fact I should infer that these latter have been washed down from the more elevated districts.

The remains of the Hippopotamus, which are by no means so common as those of the Rhinoceros, have been found in various parts of Britain, as Gloucestershire, Somersetshire, Worcestershire, Lancashire, Yorkshire, Huntingdon, Essex, Devonshire, Norfolk, and Middlesex, and in every instance in fluviatile deposits; and there is no evidence, according to Professor Owen, that it existed on our planet prior to the deposition of the *Pliocine* division of the *Tertiary* epoch. That is the last great deposit before the superficial accumulations of gravel, clay, sand, &c. Associated with the remains discovered in the parish of Burfield, in Worcestershire, my friend Mr. Strickland found a number of shells, of which he determined twenty-four species (five terrestial and nineteen fresh water); of these only three appeared to be extinct species; all the others are now existing, and indigenous to Britain, a proof sufficient, if no others could be cited, that this quadruped was associated with them in life as well as after death, and not brought from tropical regions, as also of the comparatively recent date of the animal's destruction. Sir C. Lyell, in alluding to this discovery, observes,—"The Hippopotamus is now only met with in rivers where the temperature of the water is warm and nearly uniform; but the great fossil species certainly inhabited England when the testacea of our country were nearly the same as those now existing, and when the climate cannot be supposed to have been very hot."

In Yorkshire, the bones of the Hippopotamus have been found in only *three* localities,—in the cave at Kirkdale, near Pickering, where six molar teeth and a few fragments of incisors and canine teeth were discovered; at Overton, near York, a single molar tooth; and in the present instance, which is the first on record in the West Riding; and it is an interesting circumstance, as I have already stated, that these remains indicate the quadrupeds to have been of different ages—both mature and immature, and especially when taken in connexion with those from the Kirkdale Cave, afford presumptive evidence of the aboriginal nature of the animals, which would not have been so satisfactory if only a fragment or two of a single individual had been discovered, as these might have been drifted from a neighbouring county or distant region, which is not so probable when both old and young individuals are found associated in different parts of the same county, and under different circumstances. Dr. Buckland figures two permanent molar teeth of a young

Hippopotamus from the above cave, which had just cut the gum and had not had the fangs completed when the animal perished; which proves, as Professor Owen observes, that, like the remains of the mammoth associated with them, they were of young inexperienced individuals, that had fallen into the clutches of the co-existing predatory carnivora, which made that cave their lurking place, and perfectly coincides with the conclusions which Dr. Buckland thus enunciates,—" That the facts developed in this charnel-house of the antediluvian forests of Yorkshire, demonstrate that there was a long succession of years in which the Elephant, Rhinoceros, and Hippopotamus had been the prey of the Hyænas, which, like themselves, inhabited England in the period immediately preceding the formation of the diluvial gravel."

That the above-mentioned large pachyderms, and other extinct animals, were cotemporary with the Hippopotamus in England, is also a fact clearly proved, as at Brentford, in Essex, at Durdam Down, near Bristol, as well as at Kirkdale, the bones of the Elephant, Rhinoceros, Auroch, Bear, and Hyæna, were found associated with those of the Hippopotamus.

As regards the geological age of these remains, I shall venture but few remarks. It is generally supposed that the larger pachyderms, as well as the more ferocious carnivora, were inhabitants of the Yorkshire hills during the Pre-glacial period, that is, prior to the deposit of the diluvial gravel, &c., when they ceased to exist, leaving only the more peaceful and domestic animals, as the Bovine and Deer tribe, to represent its former fauna. Such is the opinion of Professors Buckland and Phillips. It appears, however, very difficult to draw a satisfactory line of demarcation between these different periods, or, more correctly speaking, perhaps, to fix the life periods of the former inhabitants of this portion of our island; inasmuch as if the Pre-glacial and Pliocene are equivalent, then many of the large pachyderms were also existing at subsequent periods, as the Glacial, if not Post-glacial, and the evidence appears very strong in favour of the latter, for had they been destroyed by the Glacial detritus, it would naturally have consisted of boulders, &c., derived from distant regions, which is not the case. They must, consequently, have inhabited this locality after the deposit of the Great Northern drift, and been suddenly submerged by some local lacustrine flood from the Yorkshire hills, as the gravel beds and clay clearly testify, which are, as I have already stated, almost entirely derived from the rocks of the coal formation.

It is not a little remarkable that the Hippopotamus should have been the first which suggested itself as the quadruped to which several large fossil bones belonged, as early as 1669, though the difficulty then presented itself as to how an animal inhabiting the Nile should be found in Kent. Still the conclusions to which one of the early writers came were perfectly in accordance with those of the leading geologists of the present day. The Rev. J. Douglas, in a dissertation on the Antiquity of the Earth, observes,—"When we consider the great distance of the Medway from the Nile and other rivers near the tropics, where those kinds of animals are known to inhabit, and when we have no authority from the Pentateuch to conclude that any extraordinary convulsion of nature had impelled animals at that period from their native regions to countries so remote, so we have no natural inference for concluding that the deluge was the cause of this phenomenon. Taking, then, into consideration the geological features of the stratum of the river soil, and that as the Hippopotamus is known to be the inhabitant of muddy rivers like the Nile and Medway, it should, therefore, argue that this animal was the inhabitant of these regions when in a state of climature to have admitted of its existence."

I consider that great praise is due to the Messrs. Longley for the facilities they afforded in order to rescue as perfect a collection of the bones as possible, as soon as it was ascertained they were of so interesting a nature; as, without their sanction and direct interference in causing special excavations to be made, it is most probable very few specimens would have been preserved; and thus one of the most important geological discoveries ever made in this neighbourhood would have been lost to science, and the Society's Museum deprived of the most valuable series of British Hippopotamic remains in the kingdom. I believe I am correct in this assertion; for in the British Museum the specimens are very few and unimportant. The majority therein deposited are from the magnificent collection of fossils discovered in the Sivalik Hills, in India, by Capt. Cautley and Dr. Falconer; and in provincial collections we find only a molar tooth in one, a canine tooth in another, or fragments of the jaw and teeth in a third; and although Mr. Trimmer, in describing those disinterred in the brick-field at Brentford, remarks,—"The remains of the Hippopotamus are so extremely abundant, that, in turning over an area of 120 yards in the present season (1812), parts of six tusks have been found," yet, as he does not specify the exact kind of tusk, whether incisor or canine, or both, we cannot determine with certainty to what number of individuals these tusks may have belonged, or whether to more than one, as each animal has six larger tusks, besides others of an intermediate size; so that, in reality, only one specimen might have been deposited at Brentford, and the bones subsequently much dispersed.

From the few remarks I have thus thrown together concerning the discovery at Wortley of these mammalian relics, the importance of depositing even a single bone of an unknown animal in a public Museum will be evident, as it is by the accumulation of a mass of materials of local interest like the above, though apparently useless in themselves, that a vast amount of information is to be derived, throwing light upon the past history of the district, which cannot be obtained from any other source;—a chronicle of events of a far distant date; a page of history, concerning which no record of man reveals a glimpse, and which, but for such medals of creation, would be wholly unknown to us or disbelieved. For to what book, but that of nature, can we turn to gain a retrospect of the past and compare it with the present state of our island, or even this county? Where can we find traces of the mighty changes to which Yorkshire has been subject, but to the evidence which geology alone supplies? Who, on looking at the busy and crowded population of some of our neighbouring towns, with the din of machinery and commerce, or the more quiet and retired villages, would see any indication of these same spots having been, at a comparatively recent period, the sites of interminable forests or swamps, tenanted by the Elephant, Rhinoceros, Hippopotamus, Auroch, Urus, Wolf, Gigantic Deer, &c., or that our more elevated limestone tracts afforded caves for the Lion, Tiger, Bear, and hordes of Hyænas, and numerous other quadrupeds no longer inhabitants of Britain? Yet such are the facts, the indisputable facts, which geology alone teaches us in such legible characters, —"That he who runs may read!"

Having alluded in the early part of this communication to the effects of currents in transporting materials to great distances, I would beg to say a word in conclusion.

As, to persons unacquainted with geological phenomena, it may appear a startling assertion to hear of large boulders travelling from Cumberland over the plains of Lancashire and Cheshire, or even to Bridgenorth, by the mere action of water, or of the continuous streams of boulders in Forfarshire, between three and four miles broad, and in a straight line for thirty miles, yet by no other agent than water has all this been accomplished. If, however, we still want actual evidence of what a comparatively small current can produce in one hour, we have only to refer to the effects of the Holmfirth flood, in February, 1852. The materials swept from the reservoir when it burst were supposed to weigh about 50,000 tons. The reservoir was not more than a quarter of a mile in length, with a surface of eleven acres, and contained about 86,248,000 gallons of water, yet the torrent tore up the sides of the valley in some places to a depth of 10 to 20 feet, and covered the meadows with fragments of rock, sand, and gravel for a considerable distance. Amongst the comparatively small masses, however, scattered about, there were three or four blocks of stone which deserve to be recorded,—the first, a mass 7 feet in length by 5 feet in breadth and 2 feet in depth, and weighing 5 or 6 tons, was transported half-a-mile; another, 12 feet by 6½ feet, and 2 feet deep, and weighing 7 or 8 tons; and lastly, in the middle of the valley, near Upper Digley Mill, about one-third of a mile from the parent rock, was a block 22 feet long, 6 feet broad, and 3½ feet thick, and weighing about 20 tons. If, then, such were the effects of a temporary flood, caused by a body of water comparatively so small, and along a valley where its force could not be maintained, we may easily form some conception of the enormous power which a more continuous flood, with more sustained action, would possess. But what are all these, however large we may consider them, compared with many which are still lying on the precipitous sides of the mountains in Switzerland? One block of granite behind Neufchatel, 850 feet above the lake, measures between 50 and 60 feet in length, by 20 feet in breadth, and 40 feet in height. Another, in the Canton of Berne, measures 61,000 cubic feet. The largest boulder I have seen turned up during the recent excavations, is one lying near Larchfield Foundry, in Hunslet-lane, about a yard long and nearly two feet broad.

In order to exhibit more clearly the Bones obtained, I subjoin the following list, exclusive of numerous fragments, and also of those destroyed, which are enumerated as far as their identity could be made out in a previous page:—

GREAT NORTHERN HIPPOPOTAMUS. (Hippopotamus Major.)

Upper portion of the skull, with the occipital foramen.
Two portions of the upper jaw, with the molar teeth.
Portion of the lower, with molar teeth.
Symphysis of lower jaw, with straight incisors in situ.
Three of the great canine tusks of the lower jaw and fragment of a fourth.
Two of the second incisive tusks of ditto.
Three of the great canine tusks of the upper jaw.
Two of the median incisors of upper jaw.
Two of the second incisors of upper jaw.
One superior pre-molar.
Right and left scapulæ of an adult.
Glenoid cavity of an immature scapula.
Right and left humerus, with portion of a third.
Right and left radius and ulna.
Right and left femur.
Right and left patella.
Right and left tibia and fibula.
Four specimens of the astragulus.
Nearly entire pelvis.
The entire right side of the pelvis.
The ilium and portion of the os-pubis of the left side.
The right and left os-calcis.
Four of the carpal bones.
Six of the metacarpal bones.
Eight of the metatarsal bones.
One of the first phalanges.
One of the second phalanges.
Three cervical vertebræ.
Seven dorsal vertebræ.
Nine lumber vertebræ and sacrum.
Seven ribs, and numerous fragments.

MAMMOTH OR FOSSIL ELEPHANT. (Elephas Primigenius.)

Glenoid cavity of the scapula.
Fragments of the femur and tibia.
Portions of the articular surfaces of femur and humerus.
Left os-calcis.
Part of the ischium, with the acetabulum.
Fragments of tusks.

URUS. (Bos Primigenius.)

Jaw, molar tooth, fragments of tibia, and astragulus.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-FIRST, (THE ANNUAL MEETING,)

HELD IN THE HALL OF THE PHILOSOPHICAL SOCIETY, HALIFAX,

ON WEDNESDAY, NOV. 8TH, 1854.

JOHN WATERHOUSE, F.R.S., in the Chair.

THOMAS WILSON, Esq., having read a letter from the Rev. W. Thorp, resigning the office of Honorary Secretary, called the attention of the Society to the very important services rendered by Mr. Thorp for a long series of years, and how deeply they, as a body, and science generally, were indebted to his labours for the many practical and valuable Papers which he had read at its meetings on the Geology of the West Riding of Yorkshire. In consideration, therefore, of his past labours, he begged to move the following Resolution:—

"That the warmest thanks of this Society be presented to Mr. Thorp for his services during that period, and especially for his valuable contributions, from the foundation of the Society, on local Geology, which have contributed more than those of any other person to a knowledge of this important coal field."

On the motion of HENRY BRIGGS, Esq., seconded by M. STOCKS, Esq., LORD DARTMOUTH, TITUS SALT, Esq., and Joshua Appleyard, Esq., were elected Members of the Society.

On the motion of Dr. Wm. Alexander, the following Noblemen and Gentlemen were duly elected Officers for the ensuing year:—

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

The Duke of Norfolk.
The Earl of Effingham.
The Earl of Dartmouth.
Lord Wharncliffe.
Viscount Milton.
Rev. Theophilus Barnes.
Rt. Hon. Sir C. Wood, Bart.
T. W. Beaumont, Esq.
E. B. Denison, Esq., M.P.
J. S. Stanhope, Esq.
Godfrey Wentworth, Esq.
J. G. Marshall, Esq.
Michael Ellison, Esq.
R. M. Milnes, Esq., M.P.
Viscount Galway.
William Beckett, Esq., M.P.
Rev. William Thorp.
Thomas Wilson, Esq.
John Waterhouse, Esq., F.R.S.
Edward Akroyd, Esq.

Council.

Henry Briggs, Esq.
Dr. Wm. Alexander.
T. W. Embleton, Esq.
H. C. Sorby, Esq.
Michael Stocks, Esq.
Jno. Jebson, Esq.
Henry Holt, Esq.
Charles Morton, Esq.
Thomas Pitt, Esq.
Benjamin Biram, Esq.
Dr. William Paley.
R. Carter, Esq.

Honorary Secretary.

William Sykes Ward, Esq.

Honorary Curators.

T. W. Embleton, Esq.
J. G. Marshall, Esq.

Auditors.

Benjamin Biram, Esq.
G. W. Chambers, Esq.

Local Secretaries and Treasurers.

Dr. Alexander, Halifax.
Henry Briggs, Esq., Wakefield.
H. C. Sorby, Esq., Sheffield.
R. D. Baxter, Esq., Doncaster.
Thos. Pitt, Esq., Huddersfield.

Mr. W. S. Ward read the following

STATEMENT OF RECEIPTS AND EXPENDITURE

Of the Geological and Polytechnic Society of the West Riding of Yorkshire, From January 7th, 1854, to November 8th, 1854.

DR.	£.	s.	d.
By Balance in Treasurer's hands....	8	14	1½
„ Balance in Mr. Battman's hands	8	8	6
„ Subscriptions—			
From 9 Mems. at 13s. for 1852	5	17	0
„ 38 „ 1853	25	4	0
„ 35 „ 1854	22	15	0
„ Mr. Battman, on account	2	10	0
„ Mr. Solly, for Copies of his Paper	1	5	0
	£74	13	7½

CR.	£.	s.	d.
To Collecting Subscriptions	3	6	3
„ Postages and Stamps............	0	9	9
„ Rent of Museum Room, half-yr.	10	0	0
„ Messrs. Baines, on Account	10	0	0
„ Salary of Assistant Secretary, half-year, 1853	25	0	0
„ Lithographing Plates	0	15	0
„ Advertising Meetings	0	13	6
„ Expenses of Meetings	1	6	10
„ Sundries, Parcels, &c.	0	16	5½
„ Palæontographical Society	1	1	0
„ Cash in Treasurer's hands	12	16	4
„ Cash in Mr. Battman's hands ..	8	8	6
	£74	13	7½

LIABILITIES.	£.	s.	d.
Messrs. Baines, for Printing	37	13	8
Philosophical, Hall for Half-year's Rent, due August 1st..............	10	0	0
Salary of Assistant Secretary, one year, due August 8th	50	0	0
Commission to Mr. Battman	4	8	6
	£102	2	2

ASSETS.	£.	s.	d.
Cash in hands of Treasurer..........	12	16	4
Arrears to receive for Subscriptions..	16	5	0
Subscriptions for 1854 to receive	47	9	0
Cash in Mr. Battman's hands........	8	8	6
	£84	18	10

After some discussion as to the desirableness of lowering the Annual Subscription, so as to induce a larger number of persons employed in mining operations, &c., to join the Society, and thus increase its efficiency, upon which much diversity of opinion was expressed, the Chairman called upon Mr. Durden to read the first Paper—

ON THE APPLICATION OF PEAT AND ITS PRODUCTS, TO MANUFACTURING, AGRICULTURAL, AND SANITARY PURPOSES. BY E. H. DURDEN, F.C.S., AIREDALE CHEMICAL WORKS, HUNSLET, LEEDS.

The subject of this paper naturally divides itself into two parts: first, the useful applications of Peat; secondly, the useful applications of the products obtained from Peat.

PART I.

THE USEFUL APPLICATIONS OF PEAT.—THE APPLICATION OF PEAT FOR FUEL.

Hitherto, no satisfactory investigations have been made in this country, to determine the relative value of peat and coal for heating purposes; notwithstanding that we have not much less than three millions of acres of peat in Ireland, and probably not less than half-a-million of acres in England and Scotland. Some years since, Sir R. Kane estimated, from the very imperfect data then in his possession, that three tons of peat were equal to one ton of coal—a supposition that was considered by many at the time, as far too high; and statements have been made, in which five tons of peat are considered as the equivalent for one ton of coal. My own limited researches on this subject lead me to place a higher estimate on the value of peat as fuel than even that assumed by Sir R. Kane. Fortunately, we have lately been put in possession of the results of some apparently most trustworthy experiments on the value of peat for fuel, carried on under the auspices of the "Society for the Encouragement of Industry in Prussia," by Dr. Brix. As these experiments were conducted under the immediate direction of Professors Karsten and Schubarth, considerable reliance may be placed upon the results. According to these experiments, the relative value of peat compared with coal, is very much higher than has been usually assumed, good black peat having very nearly half the value of average bituminous coals.

Even still more to the purpose are the practical results obtained by Messrs. Guinness and Co., the eminent brewers of Dublin. Remembering that whilst inspecting their extensive establishment in the year 1849, I had seen large quantities of peat used there as fuel, I took the liberty of writing to those gentlemen for information on the subject. To my enquiry they kindly returned answer: "Our estimate of the value of peat is about one ton of coal to two tons of peat; but the relative value will, of course, greatly vary according to the goodness and dryness of the peat, and the quality of the coal. We think larger furnaces requisite for the burning of peat than for coals."

Mr. Henry Anderson, of Ballynacree, Ballymony, county Antrim, in his prize essay, (printed in the transactions of the Highland and Agricultural Society of Scotland,) on the employment of peat in burning clay drain pipes and tiles, states, that coals can be delivered at his works, after payment of all expenses, at 13s. per ton, either from the ports of Glasgow or Ardrossan, and the amount requisite for burning 25,000 2-inch pipes is 7 tons, thus costing £4 11s. per kiln, or 3s. 8d. per 1,000; while peat can be purchased at 6d. per guage, (a measure of 3 ft. square,) and 120 guages, or £3 worth are required to burn a kiln of equal size, thus shewing a saving in favour of peat of 31s. on every 25,000 pipes, or nearly 1s. 3d. on every 1,000 pipes; which, in an article of large consumption and little value, is well worthy of consideration.

A comparison between the calorific values of air-dried peat, and peat perfectly dried, shews the important advantage derivable from depriving the peat of its moisture. For example, whilst the mean calorific value of air-dried peat in Dr. Brix's experiments is 3.15, that of perfectly dried peat is 5.02, or more than 59 per cent. greater, and equal to more than 68 per cent. of the average heating power of coal. It must always be borne in mind, that when peat or any other fuel is not perfectly dry, it has first to evaporate its own moisture, before it can be made available to communicate heat to any other body. Amongst the many advantages possessed by peat as fuel may be enumerated,—1. The total absence of any metallic sulphurets. 2. The large amount of volatile matter evolved during its combustion, whereby its heat is diffused over a large surface, rendering it well suite for purposes requiring quick evaporation. 3. Absence of smoke in its combustion. 4. The ashes which remain never aggregate so as to form a clinker, and consequently there is little or no attention required to keep the bars of the furnace clear for the draught.

"The value of Peat as fuel," observes Mr. C. Wye Williams in his letter to me of June 6, 1854, "is but little known; in our Shannon steamers we have not used anything else for many years:—among the advantages derived was this, that the cost of fuel was only one-half what coal would have been. Again, the boilers lasted double the number of years. But the great value of peat is in connexion with the working of iron. At our works in Liverpool, we use much of it for annealing the iron plates for boiler making. The improvement in the iron is such, that it may literally be said that bad iron is converted into good iron. The proofs in this case are numerous, but must be seen before a correct knowledge of the changes could be understood. Without this annealing process, the plate, if rolled cold, cracks in connexion with the punched holes;—nothing of the kind occurs to annealed plates. The annealing process is merely the placing the plates on their edge, a ton weight at a time, in a furnace made red hot by ordinary peat, and then shut up closely, allowing the whole to cool slowly. By the following morning all is cold: the plates are then taken out for work. Annealed iron plates may be burnt cold without cracking."

In many other of the countries of Europe, peat is much used as fuel. In Holland, an immense manufacture of bricks is carried on with peat; and alum works, breweries, bakeries, and many other factories, both in France and Germany, use no other fuel. A considerable manufacture of wrought iron, arms, and general hardware is also carried on with this fuel.

COMPRESSED PEAT; OR PEAT REDUCED BY PRESSURE TO LESS BULK.

When thoroughly dry, peat may be compressed in large quantities, at a moderate expense, into one-half or even one-third of its previous bulk; and, which compressed state it will retain, provided it be preserved under cover. The lower heavy strata cannot however, be advantageously compressed, as they have a tendency to crumble and lose their consistency; but the upper and middle strata may, when thoroughly dry, be compressed under an hydraulic press. "The most effective plan, however," Mr. C. Wye Williams informs me, "is to take the peat from the bog in cut pieces about four inches thick; these are placed, a ton weight at a time, in a large hydraulic press, in layers, as you would lay bricks beside each other on the floor. Between each layer is placed a coarse cloth and deal planks, that each layer may be kept separate. The press being filled with these layers four or five feet high is worked gradually, and the great volume of water forced out, leaving the peat sufficiently dry and hard to be piled in ranges like half dried bricks, to be dried by the air but under covered sheds. The pieces are then the shape of bricks of about 1 to 1 inch and a-half thick. In this way they are hard and do not spring back to their former size, as would be the case had they been partially dried before being pressed." Much praise is due to Lord Willoughby de Eresby for his exertions in promoting the use of peat as fuel, by his indefatigable endeavours to perfect machinery for the compression of peat. By means of his hydrostatic press, 27,000 peats may be compressed in one day, with a high pressure steam engine of six horse power.

The compressed peat obtained by Mr. Cobbold's process is very compact and dense. By this process, the peat is taken as dug, regardless of quantity or quality, and thrown into a hopper, at the bottom of which are rollers furnished with strong teeth: these being set in motion, and water at the same time being admitted in a full stream into the hopper, the peat and water are drawn down together through the crushing rollers, by which means the peat is partially disintegrated. The mixture of peat and water is then conducted into a vessel furnished with revolving bars, set between corresponding fixed bars, by which means the fibrous portion of the peat becomes separated, and the mudlike mass of fine peat and water thus obtained, being thrown into filtering tanks, the water passes away through the pores provided for its exit in the sides and bottom of the filter; whence, after the lapse of a short time, the peat may be dug out in blocks of great density, and dried. A somewhat extensive manufactory is now in course of erection in Ireland, with apparatus capable of turning out from 60 to 80 tons per diem.

Various processes for compressing peat have been patented by Mr. Hills, Messrs. Laming and Evans, Mr. Rotch, &c. &c.; these are, however, for the most part only modifications of the processes above-mentioned.

Amongst the varied applications of peat made by Mr. Cobbold, I may mention the following:—

1. Manufacture of artificial Ebony from his compressed peat, (not Irish Bog Oak,) and of inkstands, vases, cups, snuff-boxes, chess-men, &c., turned out of this artificial Ebony.

2. Peat fibre for stuffing sofa cushions, extracted in his patent process, partaking equally of the elasticity of horse hair, and the softness of fine flock wool.

3. Various gradations of colours, paints, or pigments derived from refuse or residuary peat matters.

4. Solid compact peat charcoal.

The solidified peat manufactured by means of machinery, patented by Messrs. Gwynne and Son, Essex Wharf, Strand, London, (samples of which are on the table) is the best specimen of compressed peat fuel which has yet been brought out. This fuel is made up in cubes of the size of an ordinary brick, that shape having been found more convenient for stowage than any other. It contains three volumes of dried peat compressed into one, and has about the same specific gravity as coal. Its per centage of moisture has been reduced by desiccation from 25 to 6.5.

Compressed or solidified peat appears to approximate more closely than any other fuel to the ideal standard of the Admiralty Commissioners, who summed up the results of their experiments by stating, that the true practical value of coals for steam purposes depends upon a combination of the following qualities:—

1. That the fuel should burn so that steam may be raised in a short period, if this be desired; in other words, it should be able to produce a quick action.

The compressed peat burns quickly, and therefore produces steam in a short time.

2. It should possess high evaporative power, that is, be capable of converting much water into steam with a small consumption of coal.

The compressed peat possesses tolerably high evaporative power.

3. It should not be bituminous, lest so much smoke be generated as to betray the position of ships of war, when it is desirable that they should be concealed.

The compressed peat is not bituminous, and therefore does not evolve opaque smoke while burning.

4. It should possess considerable adhesion of its particles, so that it may not be broken into small fragments by the constant attrition which it may experience in the vessel.

The compressed peat is not broken by attrition.

5. It should combine a considerable density, with such mechanical structure, that it may be easily stowed away in a small space; a condition which, in coals of equally evaporative values, often involves a difference of more than 20 per cent.

The compressed peat possesses a form well suited for stowage.

6. It should be free from any considerable quantity of sulphur, and should not progressively decay, both of which circumstances render it liable to spontaneous combustion.

The compressed peat is entirely free from sulphurets, and is not liable to spontaneous combustion.

Messrs. Gwynne and Co. have patented a compound solidified peat fuel, in which peat tar is mixed with the peat previous to solidification. Dr. Letheby reports on it as follows:—" The sp. grav. of the block is as high as 1,140, and its structure exceedingly hard and dense. The actual stowage weight of one cubic foot of the material is 71.24 lbs. avoirdupois; that of Newcastle coal being about 49.69 lbs. It contains 9 per cent. of hydrometric moisture." Specimens of this fuel are on the table.

MANUFACTURE OF GAS FROM PEAT.

By the distillation of peat a large portion of gas is evolved, as much as 13,216 cubic feet per ton, which, when naphthalised, is capable of being used as a source of light—peat gas has the advantage of being entirely free from sulphur.

In some experiments on this compressed peat, Dr. Letheby found "that one pound of peat produced 6.25 cubic feet of gas, which, when burnt at the rate of five cubic feet per hour, from an argand burner with 15 holes and a seven inch chimney, gave a light equal to seven sperm candles, each burning at the rate of 120 grains per hour. The rate per ton would be about 14,000 cubic feet. The gas when purified by passing through an alkaline mixture, was found to be entirely free from sulphur, and in this respect it has great advantages over coal gas, for the products of its combustion are wholly harmless in respect of their action on books, drapery, and other perishable fabrics."

MANUFACTURE OF PAPER AND PAPIER MACHE FROM PEAT.

August 25, 1853. M. Lallemand, of Besancon, chemist, took out a patent in this country for the manufacture of paper from peat. The specification of his patent is as follows:—The material I employ in the manufacture of paper is peat, and I treat it in the following manner: I first wash it thoroughly in order to separate all the earthy from the fibrous portions, and I place these in a bath of caustic ley. After the lapse of some 24 hours, more or less, according to the strength of the ley, the fibres are removed, and are then placed for about four hours in a bath acidulated with hydrochloric acid, and kept constantly agitated therein. The fibres are next washed in fresh clean water, and are then subjected to a bath containing a small quantity of alum. The fibres are then bleached in a chlorine vat, and are mixed with 5 to 10 per cent. of rag pulp. The fibres and pulp are then placed in an ordinary pulping engine, and the pulp goes through the processes usually followed in the manufacture of paper.

The idea of making paper from peat has been successfully carried out in more than one place on the continent. Peat bogs of a considerable extent and thickness, and very generally of ligneous character, are found in many parts of Piedmont. This peculiar character of the peat appears to have first suggested its use as a material for paper making, and accordingly a number of trials were instituted at Turin, which appear to have been remarkably successful. From these experiments we learn, that certain kinds of peat may enter into the composition of paper to the extent of from 80 to 90 per cent., and into that of millboard even to 95 per cent. The other materials employed in addition to the peat, were old ropes and bagging, and the bark of the mulberry. The economy of using peat instead of the materials now employed is stated to be fully 50 per cent.

M. Lallemand's process has not yet been practically carried out in this country. The specimen of peat paper on the table, to which I am indebted to the kindness of M. Buisson Dumouriez, contains 75 per cent. of peat and 25 per cent. of rags; it resists water better than ordinary brown paper of a thicker texture. It was manufactured at Turin.

About three weeks previously to the date of M. Lallemand's patent, Mr. W. H. Clarke obtained a patent for manufacturing a substitute for papier maché and Carton Pierre from peat. By his process, the previously cleaned peat is reduced to a pulp, by soaking it for two days in a solution of about six parts by weight of potash, and six of fresh slaked lime in one hundred parts of water. The peat is then submitted to the action of a weak solution of hydrochloric acid to remove all traces of the alkali, after which it is reduced by mechanical means to a state of pulp adapted for making paper, pasteboard, millboard, papier maché trays, panels, &c. &c.

APPLICATION OF PEAT TO THE PURIFICATION OF COAL GAS.

Most specimens of peat contain a certain amount of iron; and there are some which contain this metal in very large quantities. These ferruginous peats Mr. Chisholm applies to the purification of coal gas, experience having demonstrated that peroxide of iron is the most powerful purifier that has yet been discovered.

Mr. Lewis Thompson, than whom there is not a higher authority on such a subject, states as follows:—

"I have practically used and investigated the process for purifying coal gas with ferruginous peat, lately patented by Mr. Chisholm, and from an experience of several months, can safely testify to its entire efficacy and simplicity of application. Where dry lime purifiers already exist, no additional apparatus will be required, but, on the contrary, the great power and activity of the ferruginous peat will enable any such purifiers to perform twice as much work as they can now do with slaked lime.

"As the result of a series of experiments, I have found that 18 bushels of ferruginous peat can purify 200,000 cubic feet of impure Newcastle coal gas, and upon merely blowing a current of air through the purifier for a few hours, the material becomes again fit for use, and may thus be employed an almost infinite number of times in succession. At one Gas Works I have witnessed its repeated use in this way for six months, without being able to discover any alteration in its purifying properties.

"Its effects are limited to purification from the sulphuretted hydrogen and ammonia, so that in some cases it may be requisite to use lime also for the removal of the carbonic acid of the gas. With this proviso, I express my confirmed opinion, that ferruginous peat is the most efficacious non-nuisance creating material yet offered to gas companies, and as such I recommend it to their attention for the purpose of purifying gas."

There is no smell nor nuisance when the purifying vessel is being emptied, and the peat, when it has done its work at the gas works, is worth twice its original cost from the quantity of sulphur it contains; it is purchased by the manufacturers of sulphuric acid.

In a sanitary point of view the process is most valuable, so absorbing and deodorising is this material, that where it is used throughout the various departments of the gas establishment, there is no smell whatever from the works.

APPLICATION OF PEAT TO THE DISINFECTION OF SEWAGE, &c.

The same peats which prove efficacious in effecting the purification of gas, will also prove effective in deodorising and disinfecting sewage, &c., hydro-sulphuret of ammonia being in each case the chief noxious ingredient to be removed.

In an essay on the use of peat by Professor Davy, of the Royal Dublin Society, published in 1850, that gentleman states as follows:—"I have most clearly established the facts, that all the varied kinds of peat obtained from our bogs, have similar deodorising and disinfecting properties to peat when charred, or peat charcoal; and that those qualities may be increased to a certain extent, by drying the peat and reducing it to powder. Peat readily neutralises or destroys the most offensive odours arising from putrescent matters; forming, by mixture with such matters, the most valuable manures, which will, on trial, I believe, be found not inferior to the guanos imported from South America and other localities, and which, as far as my experience has yet extended, may be rendered less liable to deteriorate by keeping than foreign guanos." "This valuable quality of peat," continues Professor Davy, "appears to me to be mainly due to creasote in combination, or to its elements in certain arrangements. Our bogs, apparently, undergo comparatively little changes in the course of ages; their antiseptic properties are well known, and the remains of the organic beings of the older times found in them, are generally in a high state of preservation."

I am inclined to think that the purifying agency of peat arises, not from creasote, but from the presence of the iron which we have seen plays so valuable a part in the purification of coal gas.

APPLICATION OF PEAT TO THE MANUFACTURE OF STEEL AND CUTLERY.

Here is a specimen of cutlery forged with peat: the compressed peat as obtained by the use of Lord Willoughby de Eresby's machine. This razor is from the manufactory of Messrs. Phelp, Wicker, and Co., of St. James's Street, late Savigny and Co., the eminent cutlers. They inform me that they have found the steel wrought with peat to be free from sulphur, which cannot be separated from coal, and, consequently purer, whatever other dross or impurity there may be worked out in the process of forging. The metal, on being tempered, is capable of taking a finer and more permanent edge, and the trial of razors, surgical instruments, &c., made therewith, has proved the advantage of this mode of manufacturing them over every other. To this fact—the absence of sulphur—Messrs. Phelp and Co. ascribe the admirable properties of all the steel articles, and especially razors, manipulated with compressed peat.

VALUE OF PEAT ASHES FOR MANURE.

The ashes resulting from the combustion of peat, are valuable as manure, for they contain salts which enter into the compositions of most kinds of plants.

These ashes form a very excellent addition to bones and sulphuric acid, and even when used alone, they are of great service in bringing forward the young turnip plant, and enabling it to pass safely from the smooth to the rough leaf, a period of great danger.

PART II.

APPLICATION OF PRODUCTS OBTAINED FROM PEAT.

These products are of three kinds: gaseous, liquid, and solid.

1. Gaseous Products.—These are chiefly carbonic oxide, carburet, and bicarburet of hydrogen, &c. &c. As these are not commercially sought after, except in the case I have already adverted to, the manufacture of gas for illuminating purposes, I need not dwell on them, but proceed to notice,

2. Liquid Products.—Ammonia, acetic acid, wood spirit, and tar, are contained in the crude liquor which comes over in the distillation of peat. The clear portion of the

crude liquor, on being neutralised with lime and distilled, yields up its ammonia, which is made to pass into a vessel containing sulphuric acid, by which means sulphate of ammonia, a salt of great value in the arts, and for agricultural purposes, is obtained. A quantity of inflammable spirit known as pyroxylic or wood spirit, or vegetable naphtha, also passes over, and is collected and rectified by repeated distillations with lime, potash, or soda. The residuum in the still is a solution of acetate of lime, which may be evaporated to dryness and sold as acetate of lime, or be decomposed by sulphuric acid to furnish strong acetic acid, which, when rectified, is used for various manufacturing purposes.

From the tar obtained by subsidence, or distillation, from the crude liquor, there are obtainable by further distillation, 1. A light oil, to which the name of peatine has been given, forming an excellent substitute for camphine, and a very good solvent of India rubber and gutta percha. Although of strong odour, it evaporates readily, and leaves no persistent smell on any article to which solutions of caoutchouc &c., have been applied. 2. A heavy oil, useful as a lubricant of machinery. 3. Paraffine, a solid substance somewhat resembling wax when purified and bleached, and capable of very useful application in the manufacture of candles.

Peat tar forms a very good paint for palings, fences, outdoor wood work generally, &c.; and the impure paraffine makes a very good grease for heavy machinery.

During the last nine years many fruitless attempts have been made, and many thousands of pounds expended, to make the obtaining of these products from peat successful in a commercial point of view. Two of these I will now notice.

The first was at Dartmoor, in Devonshire, the carbonisation of the peat being carried on in closed iron retorts, as in the ordinary mode of distilling wood and coal. Peat was used for fuel. The works were situated close to the bog, and the cost of cutting, drying, and carrying the peat to the mouth of the retorts, was but 2s. 6d. per ton.

The results obtained by the destructive distillation of 100 tons of peat, were, charcoal 33 tons; peatine 100 gallons; heavy oil 50 gallons; pyroxylic spirit 30 gallons; acetic acid 168 gallons; crude tar, of the consistence of tallow, containing paraffine, 33 cwts. 14 lbs.; sulphate of ammonia 7 cwts. 2 qrs.; 100 tons of peat were used as fuel, which gave 8 tons of ashes.

Commercially the undertaking proved a failure, not because the required products could not be obtained, but because they could not be obtained at a price which would enable them to enter into competition with the same class of articles produced from other sources.

The other attempt was that of Mr. Rees Reece. In endeavouring to carry out his object, Mr. Reece makes use of a blast furnace, lined with cast iron at the upper part; below, there is a grating or set of fire bars on which the peat is placed, under which are set the blast pipes for introducing the air necessary to maintain the combustion of the peat. The furnace is provided at the top with a suitable cover, which is raised when the furnace is to be charged, an operation done at intervals, care being taken that the charge does not descend so low as to go out. From the upper part of the furnace, is an exit pipe, the other end of which dips into a closed trough of water, from which emanates another pipe of considerable length, immersed in a condensing apparatus, kept constantly supplied with cold water. The gases or incondensable products, in their exit from the condensing apparatus, may be collected for use as fuel or otherwise; and the tarry and other liquid products pass into a suitable receiver, whence they are removed, to be separated and purified by various chemical means.

I need not take up your time with details of the immense profits which were at one time stated to be derivable from the commercial working of this process. Although the first erected set of apparatus has been taken down, and another put up; yet the result of four years' labour and expense has not been attended with sufficient success, to bring the long promised products into the market.

The successful operations for obtaining paraffine and paraffine oil from the boghead and other cannel coals, have, I believe, completely extinguished the chances of peat in these particulars; whilst coal as a source of ammonia, and wood of acetic acid and pyroxylic spirit, prove too powerful competitors with regard to the remunerative production of those liquids.

This brings me to notice the solid product obtainable from peat.

3. CHARCOAL.—In Mr. Reece's blast furnace process, no charcoal is obtained, and in the Dartmoor plan of closed retorts, the cost of preparing charcoal is too dear. Hence, the necessity of seeking for some other and cheaper mode of carbonising peat.

Peat may be carbonised in the same way that wood is converted into charcoal, viz.: in large heaps or mounds. Of course various modifications are necessary, arising from the difference between the materials thus carbonised. Peat charcoal, made in this way, is of excellent quality, and is largely used in Saxony and Bohemia, in metallurgical operations.

Mode of carbonisation adopted by the "Irish Amelioration Society," (Mr. Jasper Rogers' patent.) Immediately the blocks of peat are cut from the bog, they are placed in exposed situations, so that the air may circulate freely around and through them, and assist to drive off the moisture. Thus, in the course of a short time, according to the state of the weather, the peat will have become sufficiently dry for conveyance to the drying-house, where the remaining moisture is driven off by stacking the peat against an air-chamber, heated by the surplus heat from the furnaces.

The carbonising furnaces are of wrought iron, pyramidically shaped, the base measuring about 5 feet; they run on wheels, and are filled from the top; the mass is ignited by the introduction of some burning peat. In the course of a few hours the peat becomes perfectly carbonised, and the damper attached to the furnace being closed, the charcoal is allowed to cool.

Peat may also be carbonised in large cylindrical retorts, set perpendicularly, capable of holding four tons of material. The liquid and gaseous products are collected through a pipe passing off at the upper end, connected with a refrigeratory, and the charcoal is discharged through an aperture at the bottom. This plan is adopted in France. It is said that the charcoal made in heaps or mounds is the best for metallurgical purposes, and that prepared in furnaces and retorts is best for deodorising uses and manure.

Mr. Vignolles, C. E., has patented a process for carbonising peat by means of superheated steam. The dried peat is placed in large iron vessels, into which steam, heated to from 450° to 600° Fahrenheit, is introduced. The steam, in its exit from an ordinary boiler, is made to traverse a coil of pipe heated in a furnace, and thus acquires a temperature sufficiently high to effect the carbonisation of the peat. The charcoal is withdrawn into suitable receiving vessels, placed underneath the carbonising apparatus. This process is carried out on the large scale at Friesack, in Prussia. It is a modification of my friend M. Violette's process, for the carbonisation of wood for the manufacture of gunpowder.

Many and various processes for carbonising peat have been patented in this and other countries, but time will not allow of my noticing them on the present occasion. I now proceed to mention some of the applications of charcoal.

APPLICATION OF PEAT CHARCOAL TO THE MANUFACTURE OF IRON.

It was suggested long ago by Berthier, that peat charcoal might be used with advantage in the extraction of iron from its ores; and he also hinted at the advantage that might be gained, by mixing the pounded ore with the charcoal, compressing the whole into the size and form of bricks, and thus placing them in the furnace; the iron ore and the carbonaceous matter would thus be brought into a degree of proximity, that would probably much facilitate the reduction and fusion of the metal, at the same time that a fuel was employed, incapable of producing upon the iron any injurious effect.

In the manufacture of charcoal iron, especially that used for making tin-plates, some of the leading manufacturers have expressed a most favourable opinion of peat charcoal. They state that the peat charcoal has been proved to be satisfactory both as regards quality and yield of iron. "We find a considerable saving on the whole as compared with wood charcoal."—"We prefer the tin-plates made with peat charcoal iron, from the great additional softness which they show in all our processes, to those made in the ordinary manner."—"We are satisfied that peat charcoal makes iron equal to any produced by charred oak. The yield is about the same as we experience with good wood charcoal. The iron produced by the peat is also very ductile." Messrs. Thorneycroft, of Shrubbery Iron Works, Wolverhampton, state, "We are glad to be able to confirm the good opinion before given by us of peat charcoal.—From a further use of it, we find it produces a quality quite equal, (if not superior,) to wood charcoal." On this point nothing can be more satisfactory. (Dates 1851-52-53. Letters to "Whixall Peat Charcoal Co.")

Again, in the manufacture of marine boilers, and particularly for boilers made on the Cornish plan, many of the plates of iron, forming the internal flues, have to be brought to a red heat above 50 or even 100 times, before they are fashioned and filled to their proper places. It is needless to mention the injurious effects of bad sulphurous coal or coke during such repeated heatings, or the advantage of a pure carbonaceous coke like peat charcoal, by which, from its freedom from impurities, the quality of the iron is positively improved. "I can speak from experience on this head," says Mr. C. Wye Williams, "having had abundant proofs of its value, and having found that the iron heated in a furnace by this description of peat charcoal, has become softer, more pliant, and malleable."

Dr. Oxland, of Plymouth, in his letter to me relative to the Dartmoor peat, informs me, that "the charcoal, ground fine, was found to be well suited for foundry purposes. It has been used to a limited extent on the moor for the manufacture of edgetools, and found to produce remarkably good articles. I have used it in the Assay furnace, and have produced very strong heats with it, but it is too tender to bear the burden of the ore in the blast furnace, or of pig-iron in the cupola. At Breat, on the edge of the Moor, parties have been attempting to make iron, using the charcoal as fuel, but they have not succeeded."

APPLICATION OF PEAT CHARCOAL, AS A DEODORISING AND DISINFECTING AGENT, FOR SANITARY PURPOSES.

FILTRATION OF TOWN SEWAGE.—Much has been said and written respecting the deodorising and disinfecting influence of peat charcoal. By some, its great efficacy has been extolled to the third heavens, whilst others have equally decried its use. One of my Irish correspondents, in reply to my letter asking for information on the subject of peat charcoal, wrote "it is one of those manufactures which may turn out very useful, but which, like many other things in this unfortunate country, has been greatly damaged by being too much puffed at first, and too much expected from it." I may mention that this gentleman is agent to several noblemen in Ireland,

and shewed his interest in the promotion of the use of peat charcoal, by forwarding specimens to the Exhibition of 1851.

This reply, contains a good deal of truth; when an article of any kind has been puffed and praised too highly, and we find on using it that its value does not reach the erroneous estimate formed of it, we are often led to underrate and lose sight of the real intrinsic value which it does unquestionably possess.

The question however, is, whether peat charcoal really does possess the valuable properties assigned to it? Totally unconnected with any company or scheme for its manufacture, my own experience has led me to answer in the affirmative. We all know, that although laboratory and lecture experiments may be successful, yet utter failure may attend the application of a great and good principle in the large and commercial scale. To ensure success, a process must not only be good, but capable of practical and economical application on the large scale.

Lady Frankland Russell, of Thirkleby Park, Thirsk, has demonstrated the practical as well as economical application of peat charcoal to filtering the sewage of a town, by the construction of a sewage tank at Aylesbury, in Buckinghamshire, which has been in successful operation during the last two years to the great benefit of the locality.

I have been favoured by Mr. Yarrow, of London, Civil Engineer, with a copy of his Report to Lady Frankland Russell, on the working of this Sewage Filter; it is as follows:—

Mr. Yarrow's Report on the Aylesbury Sewage Filter.

88, St. James's Street, May 13th, 1855.

Lady Frankland Russell,

Dear Madam,

In accordance with your instructions, I have prepared the accompanying model of the Aylesbury Filter, constructed by your Ladyship's order in 1852, for purifying the town sewage by means of peat charcoal.

I have also collected the following particulars for your Ladyship's information.

1. The filter is placed at the outlet of a sewer on the Hartwell Road, and intercepts the sewage from a section of the town containing about 2000 Inhabitants.

2. The Tank is constructed of brickwork, set in a composition of equal parts of Roman cement and common lime. The filter boards are of red pine, and perforated with holes an inch in diameter. The filter is 10 feet long by 6 feet wide, giving an area of 60 feet, and the space between the upper and lower boards, forming the filter, is 2 feet 6 inches.

3. The entire cost of the tank and the filter was £27, and it was completed within 14 days.

4. The filtering medium is peat charcoal, which abstracts all offensive and colouring matter, and immediately the sewage is withdrawn from the filter, it becomes a dry, portable, and inodorous manure, fit for packing in barrels or sacks, and capable of being transported by any public conveyance.

5. The filter beds hold 30 cwt. of peat charcoal, which requires changing every four weeks, and when removed, it is found to have taken up its own weight of fertilising matter.

6. The present price of peat charcoal ranges from 50s. to 60s. per ton, but, by proper arrangements, it can be manufactured for 20s. per ton.

7. The average results of a year's working of the Aylesbury tank appear thus:—

		£.	s.	d.	£.	s.	d.
CR.	By sale of 39 Tons of Peat Charcoal Manure, at 60s.				117	0	0
DR.	To Cost of 19½ Tons of Peat Charcoal at 50s.	48	15	0			
	Labour, emptying and refilling Tank	5	4	0			
	Cartage, &c.	6	10	0			
	Repairs, Interest, &c.	2	14	0			
					63	3	0
	One Year's Profit				£53	17	0*

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* At a recent discussion at the Society of Arts, consequent on the reading of a paper by Mr. Longmaid, on charcoal, the Rev. J. B. Read remarked, "that

8. By this experiment, which has been two years in operation, it is found that an Income of £200 per annum might be derived from the town of Aylesbury, if the necessary number of tanks were constructed to purify the sewage from the remaining sections of the town.

9. The commercial test of the value of the manure is the ready and increasing sale that is found for it, and it is interesting to know, (as collateral evidence,) that the "Metropolitan Sewage Manure Company," having failed in their original objects, are now supporting the establishment at Stanley Bridge, by saturating peat charcoal with London Sewage, and selling it at £4 per ton.

Extract from Mr. Tuffnell's report for 1852 to the Committee of Council on Education:—

"The land attached to the North Surrey School, and cultivated by the boys, has been extremely productive." After detailing the results, Mr. Tuffnell proceeds: "The flow of liquid manure from a population of 700 persons, where all the ordinary operations of washing, &c., were also continually going on, was, of course, considerable. Great part of this was used in irrigating the land, and to this the large crops were undoubtedly attributable. But the quantity

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the town of Aylesbury had unfortunately given another proof of being two centuries behind-hand. The beautiful apparatus erected by Mr. Yarrow had been destroyed. Whilst it was in operation, the public could travel over that part of the road with comfort and satisfaction. They had now diverted that most offensive drain across the road, and its contents were discharged into a field on the north side of the road at a distance, he should say, of not more than two hundred yards from the high road, which rendered the atmosphere in the vicinity of it of the most offensive character; whereas, when the filtering apparatus was in operation, not the slightest taint in the air was perceptible to the passers by."

Mr. Yarrow said, "it was well known that Croydon had always been the pet town of the Board of Health, and every known improvement had been carried out there, the whole of the sanitary works being completed under its sanction. In Croydon there were about 600,000 gallons of sewage per day, and there they had the best advice as to the means of conveying it away; but, notwithstanding all the advantages they possessed, it had ultimately been determined to use charcoal filters. An advertisement had recently appeared in the papers for sixty tons of peat charcoal per month; and the manure produced might be taken on the average at double the quantity of charcoal used."

was so great, that there was still a large surplus, which, running down along the railroad caused a nuisance that was much complained of, and an indictment was threatened against the board of management. In this difficulty, a tank was built of 9 inch brickwork, 20 feet long, 6 feet wide, and 4 feet deep, with an inlet from the sewer near the top, and an outlet at the other end on a level with the bottom. At 3 inches from the bottom is placed a moveable floor of 3 inch planks, with a number of holes bored through them. On this floor alternate layers of peat charcoal and clay ashes are placed. The sewerage enters the tank at the top of these layers, soaks through them, and passes out at the bottom in a stream of pure, inodorous water. At the end of about three weeks the tank ceases to act, when the clay ashes and charcoal are removed, and a fresh supply put in. The material removed is perfectly inodorous, has increased from four to eight tons, and is now a valuable manure which fetches a considerable price. The nuisance complained of no longer exists." In May, 1854, Mr. Yarrow states, "I am informed by Mr. Westwood, the bailiff at the farm attached to the North Surrey District Schools, at Anerley, that the tank, which I constructed there in 1852, continues to act in a very satisfactory manner, and that the sewage is perfectly purified."

APPLICATION OF PEAT CHARCOAL AS MANURE.

The results of trials with peat charcoal as a manure are very conflicting and very difficult to reconcile ; serving to shew us that we have yet very much to learn with regard to the action of artificial manures. Peat charcoal alone does not appear to be of value as a manure commensurate with its cost, and it will be necessary to reduce the cost of the manufacture of this article very considerably, before any extensive applications of it, mixed with night soil and other refuse of animal products, will recommend itself to the agriculturist. At present, peat charcoal is not obtainable under 50s. per ton, and if to this be added an average cost of carriage, the price becomes raised to 60s. per ton. I question whether any profit is to be derived from its use at this price, except in such a case as its admixture with guano; this I consider to be about the best practical application of this substance as a manuring agent. Mixed with guano, peat charcoal is of very great value, inasmuch as it serves the useful purpose of absorbing and storing up the ammonia contained in this valuable manure, and giving it out again to the plant in a less rapid manner than unmixed guano would under similar circumstances; the benefit arising from this slower liberation of ammonia appears to be this, that whereas in pure guano, the plant is often stimulated in its growth before it can take up a due quantity of another important constituent of guano, viz., the phosphoric acid; in the case of charcoal guano, the supply of ammonia keeps a more even pace with the absorption of phosphoric acid, and thus a more healthy and vigorous development of the plant takes place.

When peat charcoal is made for £1 per ton, which Mr. Yarrow says it can, and which I think it may be by good management, its application mixed with night soil, &c., would, no doubt, be amply remunerative. There can be no question as to the value of such a manure; the only question is, which, in fact, is the question of questions, will it produce as good results as guano, sulphate of ammonia, coprolite, &c., of equal cost? The sale of the peat charcoal manure, the produce of the Aylesbury filter tank at £3 per ton, proves that it will, otherwise the Buckinghamshire farmers would not buy it.

APPLICATION OF PEAT CHARCOAL TO HORTICULTURAL PURPOSES.

Mr. Cuthill, the florist, of Camberwell, has sent me the following information on this subject:—

Geraniums.—These luxuriate in a mixture of 3 per cent. of pure charcoal to 1 per cent. of mould. In this material they make good saleable plants in half the usual time. Cuttings strike freely either in the pure charcoal or in the mixture.

Cucumbers.—For these I mixed the charred peat with mould during the winter, and when the plants were put into it, they grew famously and produced a heavy crop. The peat charcoal not only yields nutriment, but it affords good drainage. Cucumber tops strike root freely in pure charred peat.

Melons.— These succeed in a mixture of charred peat and soil, equally well with the cucumbers; and if a large proportion of the soil consist of peat, I am of opinion that the flavour of the fruit will be improved, more especially in cloudy, sunless seasons.

Potatoes.—I have found those manured with charred peat drier and more mealy than others to which farmyard manure was applied. In the former the foliage and stalks are more compact and firm, and when taken up the tubers were found to be clean-skinned. In my case no wireworm came near them. Where potatoes are pitted in long ridges in the open ground, a layer of peat between them and the soil helps to keep them dry, and if this heap could be covered with it below the straw, it would also be an advantage.

Strawberries grow admirably in charred peat, mixed with soil, and in the case of pot plants, they like a handful of the pure peat placed in the bottom of the pots. This latter has a tendency to prevent the ingress of worms, which do not appear to like the sharp edges of the charcoal.

Vines.—I have not yet tried the effect of peat charcoal on vines, but judging from analogous cases, I am certain that it will prove of much advantage to them, not only as a fertiliser, but also as a means of keeping the borders porous, and thereby bringing better into action the other materials of which they may be composed. Under such an arrangement much finer fruit may be expected.

In flower gardens, peat charcoal will be found invaluable, inducing, as it does, quick growth; but not over luxuriant, and consequently plenty of blossoms. Under its influence the colours of the latter are well brought out.

These experiments were all tried last year. This season I have found, that, if instead of horse dung being turned for a month before it is used for forcing, it is allowed about a week's lying, and then put into a four-light pit, and covered over with an inch of peat charcoal, all will be well. Under this system, by the time my cucumbers came up, all smell was removed. Again, gardeners are much annoyed in January and February by plants damping off. I dusted my cucumber plants in the pans every morning with peat, and I did not lose six out of six hundred. Those treated in this way throve better than the others, and produced a more healthy dark green leaf. In short, I consider the use of charred peat in a melon-ground indispensable. I have only to add, that I never had finer crops of strawberries in pots, as well as all sorts of plants before-mentioned, than I have had this summer. On frequent examination of the roots I have always found the young fibres adhering closely round the particles of peat, shewing at once the great benefit they derive from it, not only in the shape of nourishment, but also in the warmth, air, and moisture the charcoal affords, from its being so porous. If this be the case in a light soil, a good dressing must be much more beneficial to clayey lands. My potatoes have never been better. I have had many weighing three-quarters of a pound, the stems strong and woody, with not half so much water in their system as usual.

APPLICATION OF PEAT CHARCOAL AS A DECOLOURISING AGENT.

It has been proved that peat charcoal is a most effective agent in removing colour from various solutions. Port wine, infusions of cochineal and logwood, solution of sulphate of indigo, &c., are all deprived of their colour by means of peat charcoal. Experience has also shewn that peat charcoal may be used to advantage in decolourising solutions of Muscovado sugar, and furnishing colourless crystals of refined sugar. Whilst trying some experiments on this subject, a friend called on me and asked my advice relative to some 80 gallons of coloured gin in his possession, and which by being coloured had become unfit for sale. I advised him to try peat charcoal, he did so, and not only removed all traces of colour therefrom, but the process of filtration, removing probably some fusil oil remaining in the gin, imparted such a mellowness to the spirit, that it speedily became so highly esteemed by my friend's customers, that he soon disposed of the whole of his filtered stock, and has learned the way of improving his future purchases.

Peat charcoal, to be effective for decolourising purposes, must be recently made and employed in a granulated state; otherwise, as I have found, much disappointment will arise from its employment. I have applied it with success in decolourising various saline solutions, in the manufacture of which I have been engaged. Although the cost of animal charcoal is treble that of peat charcoal, the necessity of employing a much larger quantity of the latter much diminishes the economy of its use. In all cases in which flavour is concerned, I believe peat charcoal to be preferable.

ON THE SUPPOSED ANTI-SEPTIC PROPERTIES OF PEAT CHARCOAL.

Mr. Jasper Rogers, some years since, suggested the application of peat charcoal to lining the coffins of the dead, so as to effect a partial embalmment of the corpse. The recent researches of Dr. Stenhouse and others, however, shew that wood and peat charcoal hasten the decomposition of the body, instead of preventing or retarding that process; the noxious gases evolved being absorbed and oxidised within the pores of the charcoal, where they are reduced to their elementary innocuous principles.—*Vide* "*Economical Applications of Charcoal to Sanitary Purposes.*" *By Dr. Stenhouse. Published by Highley, London, price Sixpence.*

The application of charcoal to the use above-mentioned is, nevertheless, one of much importance, the general adoption of which would be attended with important sanitary results.

Mr. H. J. Traice, of Leeds, then read a Paper

ON WILLIAMSON'S IMPROVED SYSTEM OF COLLIERY VENTILATION.

In order that the causes of danger of explosions in coal mines may be so dealt with as greatly to decrease the probabilities of accident, we must either dilute the explosive air in the mine till it has lost its explosive property, or we must remove it before it can mix with atmospheric air in the proportion which renders it explosive.

According to the system I propose, the ventilating arrangements are altogether different from the method ordinarily used. What would ordinarily be the main downcast windway, is made the main upcast windway, the roadway nearest the workings being the main downcast airway. Air passages passing overhead draw the foul air from the goaf to the upcast airway. The effect of this withdrawal is to cause a current of air to pass up each of the branch roadways to the coal face, from whence it is drawn into the goaf, in the same proportion as the air is withdrawn from that waste by the action of the ventilator, which may be either a steam jet, a furnace, or a fan, as circumstances may dictate. It will be seen that by this plan of ventilation the upcast windway is an extension of the upcast shaft, drawing a portion of foul air from every goaf, and, indeed, every separate part of the mine, independent of any other. The quantity of air removed being regulated by the size of the opening of the overhead airways, the sum of the areas of the whole of which must not exceed the area of the upcast shaft.

The advantages of this plan are:—

1st. Should a blower occur opposite a goaf, the workmen can be withdrawn until it has exhausted itself, without the gas causing any injury to any other portion of the mine.

2nd. The gas would be immediately withdrawn from the lamps of the miners, for although the diffusion of gases goes on somewhat rapidly, still as there is the difference of specific gravity to be overcome, the probability of an explosion would be lessened.

3rd. When a change in the pressure of the atmosphere occurs, and the barometer falls, say from 30 to 29 inches, the atmosphere of the goaves expands in the inverse proportion, every 29,000 feet becoming 30,000 feet; but by the plan proposed it would escape by the upcast airway, instead of being driven into the workings, as in the old plan.

4th. Allowing of the possibility of an explosion, it would be entirely local in its effects, for the after-damp would not pass through the workings, but through the goaf to the upcast; the ventilation would not be disarranged as it now is by the blowing down of traps and stoppings, which frequently prevent any succour being given to those who, by an explosion, are prevented from obtaining fresh air or the means of exit.

5th. A greater facility for working the mine, by the removal of a number of the traps; a great saving in the expense of working, by a less number of trappers being required, thus giving the children of the colliers a better opportunity of acquiring a school education, by removing the temptation of a few shillings per week, for which the poor children are consigned to a dark, solitary, and monotonous employment.

6th. A larger proportion of the foul air will be drawn off, as the opening being made in the upper parts of the mine will give the carburetted hydrogen the advantage of its lower specific gravity. I may here remark that where a quantity of carbonic acid gas is eliminated, I should place openings beneath the levels of the main airways, so as to give it the advantage of its higher specific gravity.

7th. By the circulation of air in the goaf, the spontaneous combustion of the coal dust, (a frequent occurrence in some districts abounding in iron pyrites,) causing accidents of serious consequence both to life and property, would be prevented.

It is possible that the free passage of air through the goaf may be impeded by the falling of the roof of the mine, in which case one of the branch roadways must be trapped and made an upcast roadway, the necessary communication being made overhead with the main upcast windway.

The plans I have thus endeavoured to explain do not involve any costly contrivances, they, indeed, have, I believe, claims to consideration on the ground of expense, as the process of insulation and circulation could be effected more economically than at present, the ventilation being carried on quite automatically so long as the upcast shaft has a rising current of sufficient strength. But even should I have miscalculated the cost of my plan; though I am at a loss to estimate any source of expense not attending the existing modes which mine would incur, I still solemnly believe that the practical solution it offers of one of the greatest difficulties in bringing to the surface our rich stores of fossil fuel, unattended with fearful loss of life, should commend it to the dispassionate consideration of every coal owner.

The Paper was illustrated by plans of the different modes of working coal pits in use, and a model of Mr. Williamson's improvement.

A discussion ensued, in which Messrs. BRIGGS, EMBLETON, and JEBSON took part, gentlemen conversant with the working of coal mines, who expressed considerable doubt of the practicability of carrying out the views of Mr. Williamson.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-FIRST MEETING, HELD IN THE MUSIC SALOON,
WAKEFIELD, ON WEDNESDAY, MARCH 7TH, 1855.

HENRY BRIGGS, Esq., in the Chair.

The CHAIRMAN, in opening the proceedings, said he did not expect to be called on to take the chair, till he saw his name in print in the notice of the meeting. There were several Papers to be read, and he hoped some discussion would take place on them, as generally had been the case. He was so unaccustomed to preside at a meeting of this nature that his first impression was to have pleaded a previous engagement, but on second thoughts felt that such a course would have been in a manner suicidal, as he should have missed the gratification of hearing the Papers read, while at the same time it would have been like abandoning his own offspring, since he had been the first originator of the Society. He had proposed at a meeting of coal masters that they should meet and discuss the strata of their neighbourhood. This was the origin of the Society, which was at first merely a technical Society, confining its objects to one particular branch of scientific research. Afterwards it had been thought best to extend the terms and objects of the Society, and the name Polytechnic had therefore been added to its original designation. At present any subject might be brought forward in the Papers of the Society, by any member, and as there were ladies present they were at liberty to introduce, if they liked, crotchet work and cookery for discussion. The Society had been in existence from sixteen to eighteen years, and a great variety of subjects had during that period been brought forward, agriculture, chemistry, and every other branch of science having in turn been discussed. Mr. Briggs then adverted to the pecuniary position of the Society, remarking that the funds were not in the most prosperous condition, many parties who had originally enrolled themselves as Members not having paid up their subscriptions for five or six years, and which could not therefore be obtained. The subject had been considered in the Council of the Society of altering the rate of subscription. That rate at present was 13s. per annum, 10s. 6d. being the subscription, and 2s. 6d. for the Reports. It was proposed to alter the rates to 5s. per annum, Reports included, in hopes that by reading those reports the number of members would be increased five or six-fold. It was rather a dangerous experiment to try; still he hoped, if it was finally decided to be so, it would induce some parties to join, such as bottom stewards and people of that kind, who would not otherwise be likely to become members. The Society, being a West Riding Society, had held its meetings first in one town and then in another, and it was six or seven years since they had met in Wakefield, on which occasion they had still fewer present than on the present one, there being only eleven persons present, who met in the ante-room. They had many honourable as well as honorary members belonging to their Society, but they did not bring much grist to the mill. Liebig was a member, as was also Dr. Buckland, and they had other names of celebrity attached to the Society. Formerly they had a Curator and a Museum, but the specimens which belonged to the latter, consisting of fossils found in this locality, had been removed to Leeds, and now formed part of the collection of the Philosophical Society in that town. The Chairman concluded by expressing a hope that the Society would meet with more encouragement than it had hitherto done.

H. C. Sorby, Esq., F.G.S., of Sheffield, then read a Paper—

ON THE MOTIONS OF WAVES, AS ILLUSTRATING THE STRUCTURE AND FORMATION OF STRATIFIED ROCKS.

For some years past I have paid much attention to the effects of currents during the formation of stratified rocks, and to the determining of their directions in numerous places. Though I have now accumulated very many facts connected with this subject, yet hitherto I have not felt justified in publishing them, on account of there still remaining many points difficult to decide to my entire satisfaction; and though I now purpose to give an outline of my present views, yet still I consider it very probable that they will have to undergo considerable modification. So far as I have at present determined, there were two apparently distinct kinds of currents present during the formation of most stratified rocks: one produced by tidal or surface waves, characterised by moving backwards and forwards along a particular line; and the other flowing only in one direction, the origin of which I have not yet entirely ascertained, and probably due to different causes under different conditions. I might, however, remark, that in the coal strata near Sheffield, where this structure is seen in great perfection, I am of opinion that it indicates currents affecting a tideless sea, not communicating with the main ocean by a wide opening. In the lower part of the millstone grit there is evidence of oscillation, as if the tide had a slight access; which, however, does not appear to have been the case with the lower part of the coal strata, though the water must have been salt. The same is the case higher up, where genuine marine shells cease; but in the upper parts, and in the lower new red sandstone, tidal action is very distinct. I shall now, however, confine myself to the consideration of tides and waves, and, after explaining my views of their motion, illustrate the application of those principles to the geology of particular districts.

The movements of the particles of water in waves are not easily understood from mere description, and, therefore, I have constructed a moveable model to shew them. The chief points to be borne in mind are, that when the crest of the wave is passing over any spot, the water at the surface is advancing in the line of the wave's movement; whilst, when the lowest part is passing over it, the motion of the surface is in the opposite direction. This is owing to the particles moving in a circle, as will be seen from the model. The amount of this forward and backward movement depends upon the size of the wave and the depth from the surface, being equal to the height of the wave on the surface, and gradually vanishing downwards, so that at no great depth there is no motion of such a magnitude as to produce any material effect on the deposits at the bottom. However, when the wave advances from deep to shallow water, as for instance to the shores or a sandbank, there is produced, by the passage of each wave, a current moving in the line of the wave's motion, and alternately flowing forwards and backwards as the highest or lowest part of the wave is passing. When the tide rises and falls it is, in fact, a large low wave moving onwards, and when it advances into a shallower sea, a narrow estuary or strait, there is a current, oscillating in a similar manner in the line of the axis of the estuary or strait. Whatever be the direction of the wind and of the movement of the surface waves some distance from the shore, yet, when approaching the coast, and coming into shallower water, being retarded by the resistance at the bottom, they become more and more parallel to the coast line; and, where the depth is such that the currents would produce any material action on the bottom, they could not cut it at an angle of above 30° or 40°. Hence, if the wind blew equally in all directions, there would be the effects of currents ranging over an angle of double that amount, with a mean line perpendicular to the shore, and also to the axis of the estuary, if, as is usually the case, the shore was more or less closely parallel to it; whereas if the waves came more from one quarter than another, the mean line would be inclined from the perpendicular towards that side. The rise and fall of the tide causes sandbanks and shoals to be much elongated in the line of the tide currents, and hence the currents due to waves stranding on them would also generally be nearly perpendicular to the line of oscillation of the tide in the intervening channels; and this fact enables one to ascertain their position and form in ancient deposits. The author described many other peculiarities in the movements of waves, which cannot be well explained without numerous illustrations, and he has therefore confined himself in this abstract to some of the most important.

In a paper read before this Society at Huddersfield, April 15th, 1852, I showed how the direction of a current, present during the deposition of a rock, can be determined from the ripple markings, and what I called drift bedding, which may be conveniently called "current structures." Those produced by the rise and fall of the tide, or by stranding waves, are characterised by shewing that the movement was along a particular line, but first from one side, and then from the very opposite, repeated over and over again. This line may be determined by taking the mean of the separate observations. I usually take a mean for those from each side, and, representing them on a map by arrows, show their relative proportion by the length of the arrows; for there are several circumstances which cause the effective force of the current from one to be greater than that from the other. From the facts I have described, and others connected with the motions of the tides and waves, we may determine the lines of axis of estuaries or straits; the direction of the more open sea, from which the tide wave proceeded; the line of the coasts, or positions of sandbanks or shoals; the prevailing quarters of the wind, as well as probably the actual depth of the water; the velocity of the currents affecting it, and the rate at which deposits were formed at the bottom. The knowledge of these facts is, of course, extremely valuable in ascertaining the circumstances under which any particular formation was accumulated.

I purpose now to illustrate the application of these principles to particular cases; but it is impossible to do so in a complete manner in the compass of this paper without maps. I shall, therefore, merely give some of the leading conclusions. I would first call attention to the upper group of the lower green sand in the neighbourhood of Folkestone, shewing a continuous simple current in one nearly uniform direction, over a considerable space, as being a very good example of the kind I referred to, as most probably not due to tidal or wave action. I am now employed in investigating the currents during the accumulation of the Magnesian Limestone, East of Sheffield; and, though I have in no way completed my observations, yet I think they will throw much light on the subject generally, as well as on the circumstances that occurred during its deposition. So far as I have yet examined, there appears to have been a rise and fall of the tide running North-east and South-west, amongst a number of shoals on which the surface waves stranded, that are elongated in the line of the tidal currents. The intervening channels are sometimes narrow, but in other cases some miles in width. Hence it will be seen that, though the beds were contemporaneous, they were formed at very different depths; and the distribution of the organic remains agrees with this supposition. The depth over the shoals could not have been considerable, or else the surface waves would not have produced the effects that I have observed.

The wealden sandstones, in the neighbourhood of Tunbridge Wells, often shew the action of wave currents in a very satisfactory manner. On the whole, the structure agrees with the supposition of a rise and fall of the tide amongst a number of small low islands, or shoaly sandbanks, with narrow channels between them, in fact, very much like the mouth of a great river; and the same may be said of those in the neighbourhood of Hastings.

The tertiaries of the Isle of Wight and Hampshire present us with a very good example of the accumulation of deposits in an estuary. The general conclusions are, that the line of this estuary ran from West-by-North to East-by-South, which is almost exactly parallel to the axis of the Pyrenees, which were formed at the same Geological period, viz., after the chalk, and before the lower tertiaries; as though movements parallel to them had bent up the sea bed into such an irregularity as to produce an estuary, running in the same direction. Some time after this, when the lowest part of the tertiaries had been formed, the sea bed became elevated so as to produce a coast, part of which now remains at the west of the Isle of Wight, which produces the differences between the sections at Alum and Whitecliff Bays. Afterwards the estuary became more and more contracted towards the West, and was at one time probably entirely closed, though still open to the East. The facts thus deduced from the current structures agree extremely well with the distribution of the organic remains, which they explain in a very satisfactory manner.

The drift seen in the south part of Hampshire also presents an interesting example of oscillating current structure. In the same manner as the line of oscillation of the axis of the estuary of the tertiaries is parallel to the Pyrenees, that of the drift is parallel to the subsequent direction of elevation of the chalk and tertiaries of the Isle of Wight, which would determine that of the branch of the sea in which it was deposited. The fact of its structure, indicating oscillating currents, shews that whether transported or not by any sudden disturbance, as some geologists suppose, at all events its final arrangement was regulated by ordinary tidal influence.

W. S. Ward, Esq., F.C.S., of Leeds, proposed a vote of thanks to Mr. Sorby for his Paper, which was of a most important character. He considered their Society was not established in vain, if they could only produce once a year such a Paper as that which had just been read. The Chairman had expressed his regret at the small attendance on that occasion. It was no doubt a source of regret, but not in so high a degree as expressed by the Chairman. They could not expect that a very great number of persons would take a deep interest in matters of this kind—at any rate such an interest as to induce them to leave their places of business in order to attend a distant meeting. Meeting, however, was not the sole object of the Society. It had great claims on the inhabitants of the West Riding as a vehicle for the publication of the scientific researches of its Members, whether they related to this locality or not. Then, with regard to the Paper which had just been read, he would say that if it had only been listened to, it would have been of little value, inasmuch as there were few whose minds were sufficiently capacious to grapple with the arguments adduced in favour of new opinions in scientific matters without some previous knowledge on the subject. He, for one, would confess that he had not been able to follow Mr. Sorby through many of his observations; but his Paper would be printed, and it was not till then that the Members would be able to derive full benefit from its instructions. It may be said, however, that the Society was only formed for the printing of Papers, but it was also for the purpose of discussion. He trusted the members would frequently see Mr. Sorby at the future meetings of the Society.

E. W. Brayley, Esq., F.R.S., F.G.S., as a visiter, congratulated the Society on the Paper just read. Mr. Sorby's method of investigating the minute phenomena of the sedimentary deposits was quite new. His explanations of the wealden sands in the neighbourhood of Tunbridge Wells agreed with the results of former investigations on different principles—that a great estuary of variable depth had once existed in that locality. The observations made respecting the tertiary deposits of the Isle of Wight being the same as the line of elevation of the Pyrenees, were also of great interest. According to some geologists the great Himalayan chain of mountains was contemporaneous with the Pyrenees. He was not prepared to advocate or reject the theory of Mr. Sorby, but if it were correct it was very interesting to find that the tertiary deposits of the Isle of Wight were of the same age as the lofty Himalayan mountains, which were from 16,000 to 17,000 feet above the level of the sea, and which slightly interfered even with the spheroidal form of the earth. He then called on Mr. Sorby to explain the nature of the ripples on the surface of Magnesian Limestone, such as that used for the new Houses of Parliament. He also invited Mr. Sorby to show how he proved that the particles of water described a circle in the advance and recession of an ordinary wave.

Mr. Sorby then answered the first question, and with respect to the second, he stated that the motion of the particles of water in a wave had been ascertained by observing how the waves broke on a coast, and by looking at them through a telescope.

E. W. Brayley, Esq., F.R.S., F.G.S., &c., of London, then delivered a Lecture—

ON THE ESSENTIAL CONDITIONS OF THE METAMORPHOSES OF ROCKS.

Mr. Brayley, after alluding to the circumstances under which he appeared before the Members of the Society at the instigation of Mr. Ward, said that he had not had time to prepare a paper, but he had selected a subject lately discussed by the Geological Society, and which had been ably treated by David Forbes, brother to the lamented Professor Edward Forbes.

It was a subject of lamentation that the relations of chemistry to geology, and of geology to chemistry, had not been properly attended to by scientific men. Mr. Forbes, however, had followed up investigations of a combined character with respect to the metamorphic rocks of Norway, and he had endeavoured to ascertain what changes could be effected by using intensely heated iron furnaces. These experiments had led to the discussion of this subject. Mr. Brayley then proceeded to point out the nature of metamorphic rocks, in which we recognise the joint action of fire and water. He then referred to the quarries of Carrara marble in Italy, which have been worked between 2,000 and 3,000 years. This marble was pure carbonate of lime, and if burnt well it would become quick lime resembling loaf sugar. In one respect this marble resembled the crystalline rocks, such as granite, as it contained no indications of organic remains, as all sedimentary deposits do. From this circumstance it was supposed that it was a primary formation; but subsequent investigations have changed the views of geologists on this subject. It had been ascertained that the Carrara marble is not only not a primary rock, but was not older than the oolite limestone of Yorkshire. It appears to have been originally an oolite which had become crystalised from the heat of lava, and from the effect of pressure.

He then proceeded, at considerable length, to point out the effects of heat, electricity, magnetism, and crystallisation, in producing the conditions of the metamorphic rocks. Among other localities alluded to as shewing signs of such agencies, were Broomsgrove Lickey, in Worcestershire, the Carradoc sandstone in Wales, the High Force of Tweddale, the Cheesewring in Cornwall, &c. He pointed out the molecular action of these rocks, and the mode in which they sometimes assumed the shape of the columnar rocks, such as those at Fingal's Cave, and the Giant's Causeway, and clearly proved that the Logan stones, rocking stones, and many other remains existing in this country, which are generally supposed to be of Druidical origin, were really geological formations.

Mr. W. S. Ward then read a Paper :—

ON THE STRUCTURAL CHARACTER OF ROCK, AND OF MINERAL DEPOSITS, AS EFFECTED BY ELECTRICITY.—COMMUNICATED BY ROBERT HUNT, ESQ., F.R.S., OF LONDON.

An idea has long prevailed that many of our rock formations and metalliferous veins bear evidence of the disposing power of electricity. The uniformity of conditions—repeated over widely spread areas—the recurrence of the same kind of phenomena, whenever similar sets of conditions present themselves, have indicated a set of constants in nature which it is important to examine.

Our rock formations may be distinguished into three marked varieties :—*Crystalline*, such as granite, &c.; *Sedementary* or *Aggregative*, as sandstones, &c.; and *Laminated*, as slates. Those rocks which are commonly called the metamorphic rocks are quite excluded from the present consideration.

Is there any evidence that a polar force of any kind has determined the conditions of the crystalline rocks without entering upon the question of magnetic and dia-magnetic forces so fully and beautifully developed by the delicate investigations of Faraday, Plucker, and Tyndale? I would briefly state an experiment or two of my own, which appear to me to indicate the line along which investigation should be pursued.

Upon the poles of an electro-magnet, (which, when connected with the voltaic battery, exerted a lifting power of about 2 cwt.,) was placed a glass dish. Into this was poured a solution of the salt which was under examination; and it was allowed to crystallise by spontaneous evaporation, the magnet being maintained in full action. If we examine the order of the magnetic radiations, or, as Faraday calls them, lines of magnetic force, we shall find them producing curves. *See Fig.* 1.

If the crystallising salt belongs to the magnetic class, its magnetic polarity is indicated by the arrangement of the crystals. Thus, the salts of iron are found to place themselves in such a manner that these lines correspond with their longer axes. The order of arrangement, on the contrary, of a salt of the dia-magnetic class, amongst which all the earthy and alkaline salts are included, is such that their axes are at right angles to those lines. In several experiments with such salts the result has been the formation of curves of crystals. *See Fig.* 2.

Connecting such results as these with such as have been discovered by the philosophers already named, it certainly appears that magnetism may be regarded as a powerful directing agent in the formation of our crystalline rocks.

My observations on the sandstone series of rocks have been so few, that beyond an experiment which will be presently described, I have little evidence to adduce. I prefer, therefore, advancing at once to a statement of my experiments on the formation of the laminated rocks, such as clay slates.

The modes of experiment were as follow:—

Between a zinc and copper plate properly connected in a vessel prepared for the purpose, was placed a mass of clay in a very soft state, a condition, in fact, of thin mud. The electric current was developed commonly by the action of ordinary water on the zinc plate, to which sometimes a small quantity of sulphuric acid was added.

On other occasions, a voltaic battery of tolerable constancy was employed, and the clay was placed between plates of platina in another vessel, under the latter form of the experiment the results were never so decided as in the previous one; but the indications were, in both instances, of the same order. On one side, the mass of clay when allowed to dry between the plates, (the action of the current being maintained for several weeks, sometimes months,) was found to be indurated in a remarkable manner; and on the other laminated. *Figure* 3 represents the structural arrangement of masses of clay thus treated.

On one side distinct lamination had taken place, the clay breaking off in thin shales, and the depth to which this proceeded was always determined by the length of time the clay was under voltaic influence. On the other side, considerable induration was invariably produced, and this hardening was found to be due to the formation of small concretions, arranging themselves along tolerably well-defined curve lines.

The experiment, in connexion with the sandstone rocks, was one in which a mass of the Bath oolite was substituted for clay. The stone was kept under experiment for many months, and when dried, it was found that lamination had taken place on the side next the zinc plate.

Results of this kind, (although it must be admitted that a far more extended series of experiments than any which have yet been made are required to establish the fact,) appear to show that electricity does exert some powerful influence on the particles of matter as they are grouping themselves; and that concretionary nodules, such as are not unfrequently found in limestone rocks, or a laminated stone may be the result of position in regard to the line along which the force of current electricity may be acting.

Such is a concise statement of a few original experiments on the structural character of rocks. A few words now on the general character of our metalliferous deposits, and of electricity in relation to them.

The connexion of copper ore with the granite, or porphyry, and slate rocks, and of lead ore, with the limestone and trap rocks, has attracted the attention of every practical miner.

All the productive mines of Cornwall are found at a short distance from, or directly at the juncture of the granite and clay slate. So certain is this, that he would be a very unwise man who ventured to speculate in a copper mine at any considerable distance from the junction of these two rocks. All the productive copper lodes of Cornwall have a main direction from the N. of E. to the S. of W. The silver-lead lodes of Devonshire are generally nearly N. and S. If we look to the conditions of lead lodes of Yorkshire, Cumberland, and Northumberland, it will be found they all indicate a set of rock conditions of an analogous order. In the districts of Alston Moor, and of Allenheads, which I have had an opportunity of examining within the last few days, we have layers of different kinds of rock piled one upon another; hazels, or silicious sandstones alternate with limestones, and argillaceous beds. Hence we find the fissure, which we call a metalliferous lode, is filled with ore, or the contrary, according to the character of the rock through which it passes. Thus, a vein passing through a silicious rock will be small, and will contain but little lead ore; perhaps none will occur as it passes through the argillaceous beds, but it will be found to have formed in great abundance in the limestones. *See Fig.* 4.

A A and B B represent respectively the sandstone and argillaceous strata, and C the limestone, in which the metalliferous ore is always found in the greatest abundance; V V showing the course and character of the vein.

My experience does not enable me to speak with any certainty upon the effect of an alteration in the line of direction of the lead lodes of the north of England; but, as far as the copper lodes of Cornwall are concerned, I have positive evidence of chemical changes being produced by an alteration in the direction of the lode after it has been formed. I have examined several mineral veins which were originally filled with the ordinary copper pyrites, a sulphuret of copper, combined with a sulphuret of iron; these have, by a shifting of the ground, been moved more or less from their first direction.

The portion moved invariably undergoes a change. The main original direction of a lode is indicated by the line *a* and *b* in *Fig.* 5; but by a disturbance or movement of the ground to the left of the line *d d*, the direction of that portion of the lode has been changed from N.E. and S.W. to E. and W. nearly. Now the E. and W. portion of the lode will be found to be converted into the grey sulphuret of copper, and to be surrounded by masses of the peroxide of iron, arising from the decomposition of the iron pyrites.

The electricity developed by mineral veins has been investigated by Mr. R. W. Fox, Mr. William Jery Henwood, Mr. J. A. Phillips, and myself. The results, in all cases, have been similar, but considerable differences of opinion have prevailed as to the origin of the electricity detected.

The mode of examination was to connect with two lodes, or with separate parts of the same lode, copper wires, which were brought in contact with a galvanometer. In nearly all cases the galvanometric needle was most powerfully deflected, and, in some cases, swung round with extraordinary violence.

Mr. Fox is disposed to consider these currents as the electric current which exerts its disposing power on the mineral lode itself. My conclusion is, however, that it is due to changes going on within the lode itself. Since, when a mineral lode is much decomposed, the deflection of a heavy needle is produced with considerable force; but when, on the contrary, a lode is very solid, the electricity detected is very slight, and indeed, in lead lodes, where decomposition is far less frequent, the electricity, if there be any free, is insufficient to move a very sensitive galvanometer. Mr. R. W. Fox, and Mr. Thomas Jordan showed, many years ago, that by placing a wall of clay between a galvanic pair, and supplying some solution of sulphate of copper to it, a well-defined miniature mineral lode was formed at right angles to the direction of the electric current. Experiments of this class have been repeatedly made, and with a constant result.

A quantity of clay in the condition of thin cream, having been mixed up with a solution of sulphate of copper, was placed between a properly adjusted voltaic pair, which were kept in a state of excitement for more than a year; when the water was evaporated and the mass hardened, in addition to the lamination and induration already described, there was found a miniature mineral lode formed of the carbonate of copper, interspersed with the red oxide, and with, here and there, beautiful particles of native copper.

Such are the evidences for and against the electrical theory, which my experiments enable me to lay before the Geological and Polytechnic Society of the West Riding of Yorkshire.

Close observation has induced me to think that beyond electricity, there exists a force which we cannot distinctly perceive as yet, but which is gradually being developed to our imperfect senses, and, that, to this force is due many of the phenomena which we now attribute to electrical power. We detect this force in action in all porous bodies; indeed, there are evidences that it exists upon all surfaces, and, that, according to the mechanical structure of the surface, and consequently, the physical state—so is the exercise of this *surface force*. We know of no cause why granite and clay slate surfaces should be necessary to the formation of the sulphurets of certain metals, or why limestone surfaces should induce the formation of another set of these combinations with sulphur. Electricity certainly does not aid us here. Again, we know of no electrical condition which would give rise to the deposition of sulphurets of copper, tin, or lead. It is not improbable but electricity may induce the required surface condition, but we want the evidence to render this certain. I lean rather to the belief that under the general terms of molecular, epipolic, asmosa, and catalytic forces, we are but expressing a set of phenomena which belong to a physical force, differing materially from any of those with which science has made us acquainted.

My only excuse, for submitting such a very imperfect paper as this to the Society, is the hope that it may elicit discussion and examination; and, in conclusion, allow me to solicit from the members of the Geological and Polytechnic Society of the West Riding, the favour of communications bearing, not merely on the formation of metalliferous veins, but on the coal and iron deposits of the county, my desire being to obtain as large an amount of information as possible on all the phenomena connected with mines and mining.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-THIRD MEETING, HELD IN THE
TOWN-HALL, PONTEFRACT, ON TUESDAY, MAY 29TH, 1855.

RICHARD MONCKTON MILNES, ESQ., M.P., Vice-President, in the Chair.

The RIGHT HON. LORD LONDESBOROUGH, of Grimston-Park, and JOHN TOLLERTON LEATHER, Esq., of Leventhorpe-Hall, were unanimously elected Members of the Society.

The CHAIRMAN called upon MR. DURDEN, of Leeds, to read the first Paper:—

ON NEW MATERIALS FOR THE MANUFACTURE OF PAPER.— BY E. H. DURDEN, F.C.S., LEEDS.

In order to afford some idea of the increase which has of late years taken place in the quantity of paper manufactured and consumed in this country, I would call attention to a consideration of the following statistics:—In the five years, 1830 to 1834, the quantity of paper manufactured in this country averaged 70,988,131 lbs. per annum; in the five years, 1849 to 1853, the average annual quantity produced rose to

151,234,175 lbs. During the first period, the excise duty was 3d. per lb. on first class or writing papers, and $1\frac{1}{2}$d. per lb. on second class; during the second period, a uniform duty of $1\frac{1}{2}$d. per lb. was levied on all kinds of paper. This reduction of duty, on first class papers, will not alone serve to account for the great increase in the quantity manufactured: for in the year 1853, the production amounted to 177,683,000 lbs., being above 23,000,000 lbs., or 10,000 tons more than in the preceding year, and 36,000 tons over the production of 1834. Nor has there been any such great increase in the quantity of paper exported; it is the home demand which has absorbed most of the additional quantity manufactured. Three causes amongst others have doubtless operated to render this increased manufacture of paper necessary. 1. The great extension of the home and export trade, causing an increased demand for packing papers. 2. The immense circulation attained by the periodical literature of the country of late years, thus requiring a larger supply of printing paper. 3. The penny postage system, under which the number of letters passing annually through the post has increased from 76,000,000 to 443,000,000 in 1854, producing a greatly increased demand for writing papers. The consumption of paper of all kinds, of British and Foreign make, in this country, is about 175,000,000 lbs., or 78,000 tons per annum.

Estimating the gross weight of material employed in the manufacture of paper at 110,000 to 120,000 tons per annum, the increased make of 1853 over 1852 would require for its production not less than 13,000 tons of raw material, and nearly 47,000 tons over that of 1834. No wonder, then, that the price of best rags has risen from 26s. to 34s., and that of other qualities in proportion. It has been estimated that the cost of production to our manufacturers, during the present year, will exceed that which the same weight of paper would have cost in 1852, by no less a sum than £1,000,000 sterling.

In addition to rags of all kinds, large quantities of old rope, cordage, bagging, fishing nets, and old navy stores, are employed in the manufacture of paper. The waste of the Manchester cotton mills, and that of the spinning mills in various parts of the country, produce annually a very large supply of material, which is now skilfully applied to paper making, and which, when mixed with other materials of a tougher quality, produces a very useful paper. The waste of flax mills is a material in very great demand; it is employed to give toughness and strength to paper, of which cotton and similar substances form the principal part.

STRAW PAPER.—Paper made from straw is now manufactured at four or five Mills in this country, and, owing to improvements recently made in its manufacture, is getting into more general use. The principal source of expense, incurred in the manufacture, is the alkali required to dissolve the silicious coating of the straw; two tons of straw furnish only one ton of pulp. Straw paper is more of a composition than a genuine paper, as it requires the use of binding materials (plaster of Paris, &c.) to give it the surface required. It makes a good scribbling and note paper, and is pleasant to write on when well made, but should only be employed for ephemeral purposes.

FLAX PAPER.—One of the most successfully applied substitutes for rags, is that of flax. Mr. Jackson, of Pimlico, has made some excellent white paper of this material, admirably adapted for newspapers.

A Company has also been formed for the preparation of flax fibre for paper making and other purposes, but they do not manufacture paper.

POTTERY TISSUE PAPER FROM OLD ROPES, &c.—Formerly, this fine paper was made exclusively of the best linen rags; but Mr. Lambe, of Newcastle, Staffordshire, has succeeded in making equally as good a paper from old ropes and bagging.

HOP-BINE PAPER.—Mr. Barling, of Maidstone, has succeeded in manufacturing a strong serviceable brown paper from the hop-bine, and judging from the specimens of bleached bine submitted to my inspection, there cannot, I think, exist a doubt of the practical application of the fibre to the manufacture of writing paper. It is estimated that 15,000 tons of hop-bine are annually obtainable in this country, the only application of which, hitherto, has been to form shelter for cattle, as manure, or burnt to get rid of it.

PEAT PAPER.—M. Lallemand, of Besancon, Chemist, has taken out a patent for the manufacture of paper from peat. Mr. W. H. Clarke is also the patentee of a process for converting peat into paper, and using it as a substitute for paper in the manufacture of carton pierre, papier maché, &c. Peat paper is manufactured in the neighbourhood of Turin, and in some parts of Germany. The materials employed, in addition to peat, are rags, old ropes, and bagging, and the bark of the mulberry tree. It would be a very gratifying circumstance if some portion of the nearly 3,000,000 acres of Irish peat could be applied to so useful a purpose as the manufacture of paper.

COUCH GRASS OR TWITCH PAPER.—Mr. Jeyes, of Northampton, has successfully applied the common couch grass (wick) as a material for making a stout brown paper and millboard. The twitch is a well-known weed, prolific in its growth, and very troublesome to the farmer, who collects it in heaps and burns it on his land. The fenny districts of Lincolnshire are very favourable to the growth of this weed; and a company has been formed for the manufacture of paper and millboard at Stamford.

MUSTARD PAPER.—Mr. Jeyes has also patented the application of the stems of the mustard plant to the manufacture of paper.

PAPER FROM WOOD.—Mr. Schlesinger, of Bradford, has established works for the conversion of wood, of various kinds, into a fibrous pulp, capable of being advantageously mixed off with rag and other pulp in the manufacture of paper of various qualities. The cheaper kinds of wood, such as fir, pine, poplar, willow, &c., appear to answer best.

PAPER MADE OF THE REFUSE OF THE SUGAR CANE.—The late Dr. Cumin, of Bath, made some paper from this refuse, but the opinions of practical paper makers, who tried some experiments with the refuse, served to shew that the material is not well adapted for the manufacture of paper.

M. Vivien, of Paris, has rendered the leaves of trees, plants, &c., more valuable by fitting them for conversion into paper. Very excellent specimens of paper have been produced from the fibre of the hollyhock: the fibres of the Spanish rush, Espato, are capable of conversion into a paper of good quality. Lord Berriedale has patented the use of the common thistle, and Mr. Evans that of Brazilian grass. Dr. Hoskins, F.R.S., of Germany, has fully succeeded in rendering the galingale, a plant indigenous to the Channel Islands, available for the manufacture of paper, and is now converting large quantities of this material into the state of "half stuff," ready for the paper maker, to be used either alone or in combination with rag-pulp, &c. A foreigner has secured a patent, through Mr. Murdoch, patent agent, for the employment of spartum, or water broom. Mr. Guyardin, of Paris, recommends the arrow, or water arrow of Britany. Mr. Gillman, of Twickenham, claims the invention of using the fibrous parts of the New Zealand plants, *giagia* and *ti*; and Mr. Burch, of Waltham Cross, has patented the use of paper pulp from willow and other wood,—all for the manufacture of paper.

M. Flechey shewed at the Exhibition of 1851, specimens of paper made of the dwarf palm of Algeria; and M. Gratiot, specimens made of the fibres of the banana.

The cow dung paper, made by the ingenious Dr. Lloyd, of Warwick, and which obtained for him the thanks of the Society of Arts, must be at present regarded simply as a curiosity.

Dr. Forbes Royle has called the attention of scientific and mercantile men to the enormous quantity of raw material, fit for paper making, which could be obtained from the plants and weeds of tropical climes, and especially the British territories in the East Indies. Some attempts have been made both in this country and in France, to use the fibres of the plantain for this purpose; but I have failed in obtaining samples of this paper, the manufacture of which has hitherto been attempted only on the experimental scale.

All the various materials which have now been referred to, are in their native state of fibre, and many other plants, such as the common nettle, potato, and a host of others could be named as capable of furnishing pulp for the paper maker. The great question is the cost of the pulp, and its quality as compared with rag-pulp. Rags have already passed from fibre into fabric, and thus may be said to be paper half made, whereas the raw fibre has to bear the whole expense of conversion from fibre into paper.

Large quantities of jute are annually sent to this country from the East Indies, in the shape of what are technically termed "gummy bags," or bags containing various articles of East Indian export; this material, bleached by the patent process of Messrs. Smith and Holdsworth, of Langly Mills, near Durham, seems likely to be extensively employed in the manufacture of paper. The specimens of white paper, of various kinds, containing large per centages of bleached jute, are of very superior quality.

De la Rue's oxide of zinc papers and iridescent papers were shewn, and much admired. Mr. Durden also exhibited to the meeting a series of samples of new fibrous materials, lately collected on the Western Coast of Africa, by Mr. Lilley, of Birkenhead, who has patented some useful machinery for preparing the plantain fibre for manufacturing purposes. The examination of one of these specimens, suggested to a gentleman present the application of the waste peelings of the withey (large quantities of which are grown on the chairman's estate in the immediate neighbourhood), as also the liquorice root of Pontefract, as capable of furnishing good materials for paper making.

The CHAIRMAN having mentioned that he had in his possession a book printed many years since composed of papers made of various vegetable fibres, such as some of those mentioned in the communication before the meeting, inquired if Mr. Durden could afford any information as to the reason why these fibres had not been brought into use before.

Mr. DURDEN, after premising that he was unconnected with the paper manufacture, replied that, independently of the circumstance that the supply of linen rags had formerly been more in a ratio with the paper consumed, the operation of the Excise laws had doubtless interfered to prevent the introduction of many of these materials into use. When the duty was 3d. per lb. on first class and 1½d. on second-class papers, all the latter were required to be made of certain fixed materials as rope or cordage, &c.; hence an absolute restriction was imposed on the manufacture, and which continued until the equalisation of the duty to 1½d. per lb. on paper of all sorts manufactured. There could be no doubt that it would be far better for the interests of the paper manufacture as well as every other, that it should be entirely free from the trammels of the Excise. The introduction of improved and cheaper methods of preparing and bleaching these fibres has also been one reason why greater attention has of late been paid to the use of these new materials. In replying to the question as to the using up of old paper and converting it into new, Mr. Durden stated that this was now done to a considerable extent; the contents of the waste paper basket, being bleached and mixed with new pulp, made very good paper.

An extensive collection of raw materials, and specimens of a great number of the new kinds of paper added much to the interest of the communication.

The next Paper brought before the Society was:—

ON THE IRONSTONES IN THE OOLITE DISTRICT OF YORKSHIRE. BY THE REV. WILLIAM THORP, VICE-PRESIDENT, VICAR OF MISSON.

One of the greatest discoveries in recent times, connected with the geology of Yorkshire, has been the large deposit of Ironstone at a much higher position in the geological series of strata, than had hitherto ever been supposed to exist, the enormous thickness of the Oolite Ironstones in comparison with those hitherto worked, and the large per-centage of iron which they yield is very extraordinary, while the most singular thing connected with them is that they have been for generations exposed to open view, have been seen and inspected over and over again, without their real value being ever suspected; much in the same manner as the gold of California was considered to be only pyrites of iron, and large quantities of rock containing gold were used to repair the high roads, and which have recently been dug up for the gold which they contained.

In order, however, to show the comparative value of the Oolite Ironstones, I will just notice a few of those mines worked in the coal district of Yorkshire, and these are nine in number :—

1. The Ironstone above the Aston Common coal, near Rotherham.
2. The Ironstone above the Abdy or four foot of Tinsley Park, near Rotherham.
3. The Ironstone above the Kents thin coal, in Tinsley Park, near Rotherham.
4. That above the Swallow wood coal, by Earl Fitzwilliam, in Tankersley Park.
5. The Tankersley or Muscle Band Ironstone, above the Upper Flockton coal.
6. The Black Mine, above Park Gate coal.
7. That above the Thorncliffe thin coal.
8. The Clay Wood Mine, above the Silkstone coal.
9. That above Black Bed of Low Moor.

Of these the most valuable and extensively worked mine is that above the Black bed of Low Moor, wrought around Bradford, at Bowling, Low Moor, and Bierley. It yields about 1,000 tons per acre, and affords the chief supply of Ironstone in that locality. Its thickness, however, is variable, near Wike becoming so thin as to "set up" only seven inches, and it is sometimes intercepted altogether by a stone rock which takes its place. Its extent from Bradford, south, is only six or seven miles. The coal seam above which it lies, identical with the Shelley or Cumberworth bed, is, however, prolonged southwards nearly to Sheffield; and Lord Wharncliffe a few years ago at my suggestion sought for at considerable expense this Ironstone, but was disappointed. This Ironstone, therefore, is variable in thickness, limited in extent, and frequently cut off or interrupted in its course by sandstone rock, and, when thickest, yields only 1,000 tons per acre.

The Muscle Band Ironstone is more extensive than the Low Moor bed, and can be traced over a tract of country of at least fifteen miles in length, extending from Flockton to Tankersley Park, near Wentworth House. It, however, is variable in thickness, and when thickest "sets up" fifteen inches, and yields about 1,200 tons per acre.

The Ironstone above the Swallow Wood Coal extends from Tankersley Park to near Flockton; it is remarkable for being interrupted in its course for miles together by a sandstone, which, however, has the iron disseminated through it as may be seen at Darton station, where the Swallow Wood Coal is in the cutting, with a heavy red and brown rock roof, but no Ironstone in balls can be found. This bed "sets up" about seven inches, and would yield about 600 tons per acre. The Ironstones of the coal district, therefore, average from 600 to 1,200 tons per acre, are sometimes intercepted in their course, and are not nearly co-extensive with the coal seams that accompany them.

In 1848, I was asked by a friend of Mr. Osbaldeston's to go to Ebberstone Lodge, in the vale of Pickering, about ten miles west of Scarborough, to ascertain if there was any probability of finding coal, as there was a bore-hole then being made and which was 140 yards deep. The borers had already found at forty-three yards deep, a coal of two feet thick, but knowing that the true coal series must, upon the Oolite, which is itself 600 yards thick, be at least 1,000 yards deep, and that the thin coal seams in the Oolite itself are very inferior in quality, and could only be worth working when near the surface, I was about to request the bore-hole to be abandoned, when the men asked me to go about four miles to inspect an Ironstone, six feet thick, recently found in a portion of the Ebberstone Estate, which had then just been sold. Being very incredulous about an Ironstone mine existing of any such thickness, I made a tour into the valley of the Esk, and found the following strata :—

	ft.	in.	Yds.
Good Ironstone	0	10	
Dirt	0	4	
Middle bed of Ironstone	1	2	
Inferior Ironstone	0	8	
Bottom bed, good Ironstone	0	7	
Ironstone	3	3	
STRATA TEN YARDS			10
Low Bed.			
Ironstone, good	1	0	
Dirt	0	5	
Ironstone, with 7in. course at top	2	6	
Ironstone	3	6	
Solid Ironstone	6	9	

Yielding, per cubic yard, 2½ tons, or 24,000 tons per acre; the value of the Ironstone then being 11s. per ton, and the cost of getting being 20d. per ton, which was then begun to be carted to Whitby and carried into Durham to be smelted.

The questions then are—What is the geological position of this Ironstone mine? What is the probability of its extension?

It is evidently in the lias, and below the alum shale, since the latter is worked above it. Professor Phillips divides the lias into three distinct beds :—

	Yds.
1. Upper lias shale with alum	66
2. Ironstone and sandy strata	50
3. Lower lias shale	166
	282

Total thickness 282 yards, and the Ironstone is from sixty to eighty yards below the alum shale, and therefore about

200 yards from the bottom of the lias, or from the new red sandstone, which is an excellent guide to its discovery, The next question—Is this valuable Ironstone co-extensive with the lias? and can we expect to find it about the middle or near the bottom of the lias in its whole extent through England? The lias extends from the Tees to Lyme Regis, in Dorsetshire. But even before reaching the Humber the whole of the Oolite beds of the North Riding have become so much reduced in thickness and altered in character, as to be with difficulty identified. In the printed reports of the Society, of August, 1841, there is a long paper drawn up by Sir J. Johnson, Mr. Ledgard, and myself, and read at Hull, with a minute account of the Geology and Agriculture of the Oolite in the wold district of Yorkshire, in the neighbourhood of North and South Cave; where the whole thickness is reduced to only sixty yards, while in the North Riding it is at least 700 yards.

	Yds.
The lias from Pocklington to the Humber ...	25
In the valley of the Esk	282

No Ironstone of this value exists under the Wolds, since in this survey, the Rev. W. Harcourt, Sir J. Johnson, Mr. Ledgard, Captain Shaw, of Brantingham, and myself, were present, and I do not think we should have overlooked it. There is, however, no doubt about a similar Ironstone, and even a richer mine, being found about four miles south of Middlesbro'-on-the-Tees, under the Stapylton estates, and at Eston Hall it is 14 feet thick of clear Ironstone. Professor Phillips and Mr. Holt, before the Commissioners of Lunacy, deposed that in the Stapylton estates alone there are three millions of tons. This Ironstone is exceedingly rich in iron, containing 45 per cent. of iron, while none of our Yorkshire Ironstones in the coal district contain more than 33 per cent.* The following is an analysis of the Ironstone in Mr. Stapylton's estate at Eston Hall, near Middlesbro', by the late Wm. West, made in February, 1851 :—

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* Costs getting, 1s. 3d. to 1s. 6d. per ton.

Iron	45
Oxygen and Carbonate Acid	15
Silica	22
Alumina	15
Lime	3
	100

I am sorry not to be able to exhibit specimens of each, but the two Ironstones are very different in appearance. The one from Eskdale is firm, heavy, dark-coloured rock; the other reddish white, not particularly heavy, and looks in appearance like a ferruginous limestone. If these two Ironstones, or, at least, if they form one bed extending from Eston Hall to the valley of the Esk, they ought to be found on the sea coast between Redcar and Whitby; and, perhaps, a diligent search might amply repay. I believe also an Ironstone has been found much in the same geological position in the Oolite of Northamptonshire, but have no particular information respecting it.

Of course the value of these Ironstone mines in the Oolite are much diminished by their distance from coal with which to smelt them. Large furnaces, however, are at work in the valley of the Esk, and others constructed near Middlesbro'; but as it requires five-and-a-half tons of coal to yield one ton of iron, and supposing it requires two-and-a-half tons of Ironstone to yield one ton of iron, therefore twice as much coal as Ironstone is required; it is certain, that in point of economy, it would be preferable to bring the Ironstone to the coal, than take the coal to the Ironstone.

I conclude, therefore, that it is probable this Ironstone may be continuous from the valley of the Esk, twelve or fifteen miles, to near Eston Hall; and that wherever the bottom of the Oolite can be approached, we may expect to find a large deposit of iron; but, coming southwards, it is almost certain the same deposit has disappeared, although it may re-appear in Northamptonshire.

ON THE CLAIMS OF THE GIGANTIC IRISH DEER TO BE CONSIDERED AS CONTEMPORARY WITH MAN, BY MR. H. DENNY, A.L.S., CORR. MEM. ACAD. NAT. SCIEN. PHILADELPHIA, &c.

Of all the Mammalia whose remains attest to us their former existence in Britain, perhaps none possess stronger claims upon our attention than the Gigantic Irish Deer, from the number, magnitude, extraordinary state of perfection, and singular association of its bones; as also from the fact of its having been almost entirely confined to certain parts of the British Isles. That the date of its extinction has been geologically recent, and that it was also one of the last which ceased to exist, we have abundant evidence. But whether its period of active life was prior or subsequent to the creation of man, is a very debateable and doubtful point, as also the causes which brought about its extinction. Individuals, eminent for their scientific labours, are divided on this question, which is one of no little importance, involving as it does, the geological age of other large quadrupeds which are allowed to have been its contemporaries. Such being the interest of the subject, and as the West Riding supplied the first British example of its remains, I conceive it not unworthy to occupy the attention of this Society for a few minutes. I shall therefore more especially consider the subject under the following heads:—1. Its recent extinction. 2. The causes of its extinction. 3. Its claims to be considered as contemporary with man; and in so doing shall adduce such evidence in support of each as I have been able to extract from various sources.

The Gigantic Irish Deer, (Megaceros Hibernicus) more familiarly known as the Irish Elk, from the earliest discovery of its remains having been made in Ireland, and being still found there in greater abundance than in any other part of Europe, was first described by Dr. Molyneux in the Philosophical Transactions for 1697—since which period its bones have been discovered in various parts of this Kingdom, as also in France; but in no locality in such a state of perfection, or in such numbers as in Ireland and the Isle of Man. No specimens have hitherto been found in Scotland. South Shields is the furthest part in the North of England where fragments were found, beneath 12 feet of clay, in a brickfield, during the month of July, 1854. But if, from the Isle of Man, we pass to Lancashire, we find their bones occur in greater abundance than in any other part of England. Portions of the skeleton of this animal have been found in Essex, Devonshire, Norfolk, and Yorkshire; but in every case these have been few and scattered. It is less abundant in France than in England, but extends into Germany along the Rhine, and in a southern direction as far as the plains of Lombardy. The first instance, however, as I have stated, of which we have any record of its exhumation in England, was at Cowthorpe, near Wetherby, in the West Riding of Yorkshire, in 1744, when a fine head and horns, weighing 68 lbs., were found at a depth of six feet in a Peat Moss. These horns were supposed not to have arrived at their full growth from the circumstance of their being still covered with the velvet coating, a fact of considerable importance as bearing upon the principal object of this paper.

The first point to which I call attention is *The proofs of its recent extinction.*

The most conclusive argument, in favour of the recent existence of any animal whose remains have been exhumed, is in their having undergone, comparatively speaking, but little change,—that not only the structure of the bones is perfect, but their constituents remain in a state of combination. Now, to prove that this is the case with the bones of the Megaceros, I shall adduce the following evidence :—

Dr. Hart in his pamphlet on the Fossil Deer of Ireland, gives the following analysis of a portion of a rib :—

Animal Matter	42.87
Phosphates with some Fluates	43.45
Carbonate of Lime	9.14
Oxides	1.02
Silica	1.14
Water and Loss	2.38
	100.00

He then, with a view to ascertain the state of the animal matter, submitted a portion of bone to Dr. Apjohn, of Dublin for examination, who reported as follows :—The bone was subjected for two days to the action of dilute Muriatic Acid, when examined at the end of this period, it had become as flexible as a recent bone submitted to the action of the same solvent. The periosteum was in some parts puffed out by Carbonic Acid Gas disengaged from the bone, and appeared to be in a state of perfect soundness.

To a portion of the solution of the bone in the Muriatic Acid some infusion of galls was added, which caused a copious precipitate of a dun colour. This proved to be Tannate of Gelatine, mixed with a small portion of the Tannate and Gallate of Iron. The cartilage and gelatine, therefore, so far from being destroyed, had not been perceptibly altered by time.* Archdeacon Maunsell found the marrow in some of the large bones changed into adipocere, and from these he caused some soup to be made, and sent a sample to the Royal Dublin Society.

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* Hart, p. 19.

It is stated by Mr. Hart, that, at the time of the battle of Waterloo, this event was celebrated by a bonfire made of a heap of these bones, in a village in the county of Antrim, which gave out as good flame as the recent bones of horses which are usually burnt on such occasions.[*]

Mr. Richardson, of Dublin, says,—He has frequently peeled off the periosteum from the bones, and that quantities of a substance called mineral tallow have been found near the osseous deposits of this Deer, which he believes to have been derived from them.[†]

Some years since, a portion of the leg of a Giant Deer, with part of the tendons, skin and hair upon it, was exhumed with other remains from a deposit on the estate of H. Grogan Morgan, Esq., of Johnstown Castle, county of Wexford. This leg was exhibited in the Lecture-room of Mr. Peel, Veterinary Surgeon, Dublin.[‡]

In the *Zoologist* for 1847, it is stated that Mr. Glennon, of Dublin, had obtained a skull of the Giant Deer with portions of fatty matter, flesh, and skin still attached to the forehead and lower parts of the head, and that the fatty matter bore the impression of coarse hair, and burned readily when held in the flame of a candle.[||]

As the occurrence of the leg of the Deer, still retaining its skin and tendons, appeared to be the most conclusive evidence of the *recent* existence of the animal, it was very essential to authenticate the statement. I therefore wrote to Mr. Morgan asking if such was the fact, and also what portion of the leg he had, with the colour of the hair, which I considered an interesting point to determine, to which Mr. Morgan politely replied " The leg which you allude to, I found in my father's museum, and made it a present to the Royal Dublin Society some years ago. It was that part of the leg from the knee to the hoof, which was perfect, and the hair was tan colour and short."

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[*] Hart, p. 20. [†] Gigantic Irish Deer, H. D. Richardson, p. 11.

[‡] Zoologist, 1847, p. 1592. [||] Ibid, p. 1633.

The recent existence of the Megaceros is also inferred from some of the localities in which its bones are found being the sites of lakes, known as such during historic times. In Ireland these situations are generally connected with the remains of ancient forts, to which I shall shortly refer. In the Isle of Man the limited district named Ballaugh, from whence the greatest number of bones have been procured, is, according to Dr. Hibbert, nothing more than a corruption of the name Balla Lough or Lake, the place of the lake, one of which remained at so recent a date as to be actually described in a map of the Isle of Man, published in 1656, by James Chaloner, in which, other ancient lakes, now obliterated, are also marked down and named. The existence of other large lakes, within the historical period, is attested by ancient records, and is inserted in a map of the island, prepared as early as 1595.

Lough or Loch Gûr, a lake near Limerick, where numerous bones have been found, is said to be particularly noticed in Pepper's History of Ireland. These sites are generally indicated by a wet hollow or morass, filled with aquatic plants, as the Equisetum, and others of a similar character; and, when the lacustrine marl is penetrated through, are suddenly inundated with water from the subsoil. The calcareous tuffa may be partially derived from the relics of fresh-water shells which abound and breed in lakes, and even the shallowest pools; and as their death and reproduction is very rapid, a considerable amount of calcareous matter is speedily accumulated.

Not the least extraordinary circumstance connected with the history and extinction of this animal, is the singular fact that it appears to have been almost exclusively confined to two isolated spots—Ireland and the Isle of Man; for as I have already stated, although it has occurred in various parts of the kingdom, these examples have been fragmentary, and, in no one instance, has anything like an entire skeleton been found, while, on the contrary, in the two former islands, the bones are of comparatively frequent occurrence. The Irish specimens alone, indeed, would amount to ninety-five per cent. of all that have been exhumed. A single dealer in Dublin, Mr. Glennon, had, up to 1846, sold four entire skeletons, and twenty-two heads and horns. The congregating of the Megaceros in the above localities however, has not, so far as I am aware, been in any way explained. I would therefore suggest the following theory, which has been adopted by Dr. Mantell, under very similar circumstances, to account for the localisation of the bones of the Moa. He says,—From the great numbers of the largest species of Dinornis that must formerly have existed, and the remarkable form and strength of their thighs, legs, and feet, constituting powerful locomotive limbs, well adapted for traversing extensive plains, it seems probable that these stupendous terrestrial birds were not anciently confined within the narrow limits of Modern New Zealand, but ranged over a vast continent that is now submerged, and, of which the isles of the Pacific are the culminating points. May not the Megaceros therefore in like manner, have formerly ranged over a large continent now submerged, of which Ireland and the Isle of Man were the highest points? To these spots the animals would be driven in numbers as the intervening land was gradually covered with water, and here subsequently would continue, thus isolated, to increase, until still further physical changes on the surface of the existing land partially hastened their extinction, which would be completed by the first colonists who arrived at these islands, as well as by the repeated attacks of carnivorous animals, as the bear, wolf, &c., which might be alike restricted to the same isolated locality.*

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* Since I propounded the above hypothesis, I have been much gratified to find that the Rev. J. G. Cumming, who has minutely examined the geology of the Isle of Man, more than confirms my crude theory,—"He supposes that there was a

The last argument I shall adduce in support of this point, is founded on the fact that many species of animals which are known to have existed previously to the Giant Deer, or have been its contemporaries, are still common, or have been extirpated during historic times. In Ireland, the remains of the Red Deer frequently occur with those of the Megaceros in the lacustrine marls. Fragments of shed horns of the Red Deer were found in Kirkdale Cave, and also in Kent's Hole, at Torquay, associated with the horns of the Megaceros and Strongyloceros, all of which show the effects of gnawing, and consequently indicate that all three species co-existed in England with the Hyæna. Remains of the Bear, Badger, Otter, Beaver, Wolf, Fox, Hare, Rabbit, Water Rat, Bank-vole, Pole-cat, and Stoat, have been found not distinguishable from the present species, and which were all contemporaries of the Megaceros and the large Pachyderms. Here then, it is extremely difficult to comprehend how some of these animals so minute should have continued from pre-adamite periods down to our own times without any special protection, which, from their very nature, they are not likely to have had; and how can we be certain that the remainder, or, at least, the majority of them may not also have been contemporary with man, as some of the former have ceased to exist in Britain, in consequence of the physical changes in the surface of the country, as well as from man's persecution; and it would be quite as hopeless now to expect to find a recent Bear, Wolf, or Beaver, as it would a Megaceros or a Mammoth? Yet we know that all the former have inhabited Britain during historic

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period when the Isle of Man presented the general outline which it does now, when a gradual submergence to the depth of 1,600 feet took place, after the deposit of the Boulder Clay formation. Secondly, a quiet and continuous emergence took place of sufficient extent to lay dry the whole area of the Irish sea, and thus to connect the Isle of Man with the surrounding countries, and these countries with each other, and over the plain so formed the Megaceros Hibernicus immigrated into these regions, as its remains are buried in fresh water deposits, formed in depressions of the drift gravel. Subsequently and lastly, a period of subsidence occurred to a partial extent, which again separated the two islands."—*Journal of the Geological Society*, 1854, *No.* 38, *p.* 215.

times, and in succession, disappeared. The brown Bear infested the mountainous parts of Scotland, according to Pennant, as late as 1057; and Professor Owen says the most recent formations in England contain remains which can scarcely be regarded as fossil, and which, if not perfectly identical with, indicate only a variety of the same Bear which is still common in many parts of the European continent. The entire skull of the common Bear (Ursus Arctos) in the Woodwardian Museum, Cambridge, was found in Manea Fen, Cambridge, from whence other specimens have also been procured.

The Wolf existed in Scotland until the year 1680, and in Ireland until 1710, but in England was extirpated much earlier.

The Beaver existed in Wales in the twelfth century, and in Scotland towards the end of the fifteenth century. The Badger has been found in the red crag at Newbourn, in Suffolk, and is consequently, as Professor Owen states, the oldest known species of mammal now living on the surface of the earth. He also says, the Otter must have lived before the fen lands began to accumulate! Now, as many of these quadrupeds are found in formations of precisely similar date with the larger extinct Pachyderms and Ruminants, and also accompanying their remains, why may not the latter also have become extinct in succession from similar causes, and yet in comparatively modern times, before any historic record would indicate their existence?

What are the Causes which have led to the Extinction of the Megaceros?

In our endeavours to account for the extinction of any animals from a country in which they are known to have been plentiful at former periods, we have two different causes to investigate, in order to arrive at accurate or probable conclusions—1st. The influence which man may have exercised in their extirpation.—2nd. The physical changes which the surface of the country may have undergone, alike prejudicial to their food and habits. Neither of these causes, however, taken separately, will satisfactorily explain why animals of the same genus, the same habits, living at the same period, and in the same country, should share a different fate, when the food, economy, and the power of providing for safety would be alike possessed by both; as, for instance, —the Red Deer and Gigantic Deer, now, the mere change of climate alone would be destructive to both, as also to other animals less able to resist the vicissitudes of seasons, than their more powerful contemporaries. If, however, to the physical effects, which may have operated powerfully, we also add the supposition that their extirpation has been partially accelerated by their importance to man for food and clothing, their extinction like that of many other animals is more easily accounted for. Such, however, is not the generally received theory, as will be seen by the opinions I shall adduce, all of which attribute it to physical and climatorial changes alone.

The first writer on the subject, Sir Thomas Molyneux, conceived that a sort of distemper or pestilential murrain might have cut off the Megaceri, and connecting this view with the remains of many of them being found in one place, he supposed, that as these animals had lived together in herds, they had died together in numbers. This view, he considered, strengthened by the fact, that a distemper in particular seasons carries off whole herds of the Rein-deer. In a communication I received from my friend Dr. Ball, of Dublin, who has carefully considered the subject, he says, my notion is, that the principal depôts of the remains were formed thus:— When the lakes were still more numerous than they are now, and the country much colder, herds of Deer crossing the ice fell in, (we know such things to occur elsewhere *i. e.* America,) the bones then remained at the bottom until covered up in marl, these lakes being subsequently drained, peat formed over the marl, and thus we find them.

Dr. Scouler, however, in an able paper in the Journal of the Geological Society of Dublin, suggests a somewhat different cause,—that of submersion in the semi-fluid peat, or miring, as we know appears to have been the case with the Mastodons in America. He observes,—The mere pursuit of the Deer by beasts of prey, if not by man, could not alone have caused its destruction. Unless increase of forests and bogs had narrowed the means of obtaining food and of escaping from danger, the Gigantic Deer might long have stood its ground like the kindred species. For if the Swedish Elk still survive in spite of having had to contend with man for so many centuries, some other cause must have contributed to the disappearance of this species so early. For Ireland, in which this fine animal most abounded, appears to have been a country peculiarly fitted for its preservation, having a favourable climate, and supplying abundance of food at all times of the year, its mild winters always affording some verdure, as no facts warrant the supposition that any change has taken place in the climate of Ireland since the period when the Giant Deer first appeared upon it. It was contemporary with animals which live in the country at present, and was, of course, adapted to the same temperature as they are. The vegetation which afforded it food, still exists, and the climate probably remains unchanged; if, indeed, any difference has occurred, it has become milder; while Sweden, the country of the surviving species, is locked up in frost for nearly six months in the year.

We can easily contemplate, he elsewhere observes, a period, and not a remote one, when the country abounded in shallow lakes, and the more elevated parts were covered by magnificent forests of the pine, yew, and oak; and even within a very recent historical epoch, a great part of the country was one immense forest, and great part of the remainder was one uniform surface of bog. The Deer could not subsist in the dense forests, the asylum of its foes, and which its large antlers prevented it from entering. The obliteration of the lakes, and the growth of peat in those situations where the drainage is imperfect, would, therefore, gradually narrow the domain of the Gigantic Deer. But while thus diminishing his means of subsistence, it would also limit his means of escape from danger; while the chances of being immersed in the semi-fluid peat and marl would every day increase. In consequence of this, great numbers would sink in the bogs and there perish. The destruction of the Deer by this means would not result merely from its own inattention, but whole herds, urged by their fears, would thus be destroyed in attempting to escape from their pursuers. Dr. Mantell says, groups of skeletons have been found crowded together in a small space, with the skulls elevated and the antlers thrown back upon the shoulders, as if a herd of Deer had fled for shelter, or been driven into a morass, and perished on the spot.*

In the year 1847, while a new watercourse was being cut through the bog at Ballybetagh, in the parish of Kiltiernan, thirty heads, horns, and bones, of the Gigantic Deer, besides those of the Rein-deer, were found within a space of one hundred yards in length by four yards wide, imbedded under the turf, in a vegetable compost containing leaves and grass. Now this large number, in so limited a space, also seems to point to the sudden destruction of a herd by submersion.

From the circumstance that the remains of the Megaceros almost invariably occur in marl, Dr. Hibbert conjectures, that the majority of the animals, whose bones are there found, may have perished from natural causes, rather than from violent means, as he remarks that pools in which marl is apt to accumulate are often the very spots selected by graminivorous quadrupeds, particularly of the Deer kind, as watering places, and hence an animal during sickness, either in company with the herd to which it is attached, or apart from its companions, may have frequented a familiar watering spot in order to quench its thirst, and, sinking in the soft marly substance which has accumulated round the margin of the lake, may have in vain exerted its limbs, enfeebled by disease, to disengage itself, and in this situation have actually died. Some of its bones may have been dissipated by the action of the atmosphere, and some may have been borne away by carnivorous animals; while the remainder may have owed their preservation to rains, which had washed them deeper in the lake, where they would be gradually enveloped by shell marl in the process of filling up the lake. In confirmation of this idea, he cites the vicinity of Altringham, in Cheshire, and Wallisey Mere, where numerous remains of the Red Deer have been disinterred from marl deposits, and where the remains of several hundred skeletons of quadrupeds have been procured from five or six small lakes in Forfarshire, where shell marl has been worked, such as the Stag, Ox, Boar, Horse, Sheep, Dog, Hare, Fox, Wolf, Cat, and Beaver. In the greater part of these lake deposits, as Sir C. Lyell observes, there are no signs of floods, and the expanse of water was originally so confined, that the smallest of the above quadrupeds could have crossed by swimming; but Deer, and such species as take readily to the water, may often have been mired in trying to land where the bottom was soft and quaggy, and in their efforts to escape, may have plunged deeper into the marly bottom, while others may have fallen in when crossing the frozen surface in winter.

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* Petrifaction and their Teachings, p. 456.

While the different writers just noticed, suppose that no extraordinary inundation was the cause of their destruction, Archdeacon Maunsell conjectured that the Megaceri, in

Ireland, at least, had been destroyed by some overwhelming deluge, and that they were probably drowned upon the hills where they had taken refuge as the waters rose, and that as they subsided, their carcases were drawn from thence into the valleys in which they are generally found; that the agitation of the waters occasioned the dispersion of the bones when the ligaments were decomposed, which thus accounts for the scattered position in which the bones invariably occur.

Dr. Hibbert, however, in describing the situation in the Isle of Man, where the bones occur, observes,—It is fatal to the notion that a herd had been destroyed by any sudden and unexpected flood, for it is difficult to conceive of any ordinary torrent, however rapid it might be, which could have succeeded in preventing the animals, on any such emergency, from securing their escape by repairing to the numerous eminences, which are immediately contiguous to the marl pits in which their bones are at present found.

The Claims of the Megaceros to be considered Contemporary with Man.

As, then, it appears probable that the extinction of the Megaceros was principally brought about by the gradual operation of natural causes, the next question to consider is, whether the last remaining stragglers of this noble animal were contemporary with the earliest human settlers in Western Europe; and if so, whether man may not also have co-operated in extirpating the species. This is a point invested with especial interest, and the evidence in support of such a supposition to which we must refer, is both historical and geological. Dr. Hibbert has ingeniously attempted to prove that the Megaceros was not only known to the Romans and exhibited in their games, but actually existed in the wilds of Prussia as late as the year 1550. The former of these points, however, I by no means think he has succeeded in establishing, as the passages from

Julius Capitolinus and Oppian, upon which he bases his argument, are not sufficiently definite to warrant us in supposing that under the designation of Cervi palmati or Cervus euryceros, the Megaceros in particular is alluded to, especially when we know that the Elk and Fallow Deer were exhibited and distinctly mentioned by Cæsar, Pausanias, and Pliny. I am, however, by no means disposed to agree with some writers, that the most powerful argument against the probability of the Giant Deer having existed during historic times, is the silence of our earliest historians; viz., Cæsar and Tacitus on the subject, who it is presumed would have been familiar with it after the subjugation of Britain! This apparent negative testimony, I consider, ought to be received with due caution, from the fact, that the animal does not appear to have been extensively, but on the contrary, very partially distributed, and consequently less likely to have become generally known to new settlers in the country; and also that the Elephant, Hippopotamus, Rein-deer, and Bear, were supposed not to have been indigenous in Ireland, solely because no historic notice was in existence respecting them. Yet the bones of all these animals have been found, and that the large cave Bear was contemporary with the Megaceros is satisfactorily determined, and was probably, as Dr. Ball remarks, the carnivorous restrainer of the increase of that mighty ruminant in Ireland. The Roman historians have left us no indication that the Elk was ever a native of Britain, yet a tolerably well authenticated instance is on record of the horn of this animal having been exhumed in the Isle of Man, in this same formation as the Megaceros; but whether introduced at a remote period by the Scandinavian settlers, it is impossible to determine. The other authority upon which Dr. Hibbert rests his belief that the animal was not extinct in 1550, is derived from a scarce work by Sebastian Munster, dedicated to the Emperor Charles V., of Germany, who, in describing the well-known animals of Prussia, mentions a species of Deer the height of a middle-sized horse, with very large horns, which was evidently becoming scarce and little known, and in order that no doubt might remain of its being an inhabitant of the wilds or marshes of Prussia, he ordered a drawing to be made from nature of this animal, which accompanied his work; as also a representation, expressly made for him in Prussia, of the northern Elk, the form of whose horns he accurately describes: he also mentions another Deer, many of whose horns were to be seen among the Augsburg merchants, said to be imported from England, which is supposed to be the Fallow Deer. Munster's authority in this instance, however, is considered of no value by some authors, from the circumstance that like most early writers, he indulged in the belief of the marvellous. I do not wish it, however, to be supposed that I am insisting on the Megaceros and Munster's Deer having been identical! By no means! But having quoted his testimony, I feel with Dr. Hibbert, that we ought not to be too severe in our criticisms on his labours as a natural historian, since it really does not appear we can bring positive evidence that our animal had ceased to exist.

Professor Goldfuss, in searching the records of his country, points to a verse in the very ancient and celebrated poem of the Niebelungen, where, in the description of a hunting match in the forest of Worms, the hero Sifrid slays, according to the earliest or St. Gall manuscript, the Urus, the Bison, the Elk, and a fourth animal, a fierce Schelch, which he considers is the Megaceros; some commentators have referred it to the Stag, but as this supposition is not based upon any authority derived from other works, it is quite as reasonable to accede to the Professor's idea, more especially as the ancient Teutonic names of the Elk were what they now are; and as the Elk and Stag are distinctly named in the same verse besides the Schelch, some other beast of the chase is obviously indicated, which may thus have been the Megaceros, for anything that can be positively asserted to the contrary.

Lastly, Whitaker, the historian, of Manchester, thinks that the Moose Deer, as he calls our animal, was in existence while the Romans occupied England, and even that the race of dogs by which it was hunted, still survive as the Segh Hound of the ancient Britons. Archdeacon Maunsell, in his letter to Lord Northland, says,—"I have also a skull of a dog of a large kind, (at least, of a carnivorous animal), which I found lying close to some of the remains of the Deer, and which I will transmit with the bones of his old acquaintance." Now this might have belonged to one of the pursuers of the Deer, either Dog or Wolf, killed by the powerful horns of the latter, when at bay; or it may have been that of a Bear, which, I have already noticed, was a contemporary inhabitant of the district. Dr. Hibbert states, in the Edinburgh Philosophical Journal, that there is a Runic monument at St. Michael's, in the Isle of Man, representing an animal of the Deer kind with broad horns, which are extremely large in comparison with those of other animals engraved on the same monument, in the act of being worried by a Dog. He also inserts a communication which he had received from Dr. Milligan, of Edinburgh, to the effect that, in the latter part of 1824, three large Elks had been dug up in Ireland, and near them, in a stratum of marl, were found the skeletons of three Dogs, and at a little distance were discovered the skeletons of several Men. This last circumstance I have not seen substantiated by any subsequent writer, which, from its important character, is somewhat remarkable, and leads to the suspicion that there is some error in the statement, at least as regards the human skeletons. Pepper, however, in his History of Ireland, (a very scarce book), expressly states that the (then) ancient Irish used to hunt a large black Deer, the milk of which they used as we do that of the Cow, the flesh serving them as food, and the skin for clothing. The latter part of which statement is somewhat corroborated by a communication of the Countess of Moira's, in the seventh volume of the Archæologia Britannica, of the discovery of a human body in gravel, in a bog, under eleven feet of peat, in good preservation, and completely clothed in antique garments of hair, which her Ladyship conjectured might be that of the Giant Deer. Professor Owen, in alluding to this supposition, makes the following objection to its probability:—But if any Megaceros had perished, and left its body under like circumstances, its hide and hair ought equally to have been preserved. In reply to this objection, Mr. Richardson says:—That it is known that of all animals with which we are acquainted, the Deer becomes soonest putrid; and consequently the coat would very soon become loose. I cannot substantiate this assertion from personal knowledge; but I would respectfully remark that because we do not find the bodies of the Deer in equal preservation with that of the man alluded to, it does not furnish a conclusive argument of the improbability or fallacy of the former suggestion, inasmuch as the human and Mammalian remains may probably have been deposited under very different circumstances. Those of the Deer, in the majority of cases, having fallen into shallow water, either from the effects of wounds or natural causes, would be subjected to all the vicissitudes of submersion and emergence arising from rains and temporary floods, and consequently decomposition would commence before being entirely buried up in marl. The man, on the contrary, though clothed in a skin garment, had that skin doubtless prepared, however rudely, by some process of tanning and drying, and might have been suddenly engulphed in a morass, by which means little or no change could take place, though it might remain for centuries in the tanning liquor; and it is, probably to this preservative principle, that the leg previously alluded to by Mr. Morgan, still retained its integuments; and it is more than probable that other portions of this animal might have been secured at the same period, but were neglected solely from the very fact of their recent appearance, as considerable difference is observable in the colour of the bones of the Deer, which may arise from the situation in which they were buried. A fine head, which I obtained from Mr. Glennon, for the Philosophical Society of Leeds, was nearly as light coloured as that of a recently slaughtered Ox, while they are generally much stained by the tannin and iron, and, occasionally, partially incrusted with pale blue phosphate of iron. Lastly, Sir William Betham, whose antiquarian knowledge, as connected with Irish history, is said to be extensive, in a conversation with Mr. Glennon of Suffolk-street, Dublin, stated to him that he had found some bronze or brass tablets with an inscription upon them, attesting the fact that the ancient Irish fed upon the flesh and milk of a great Black Deer.

I shall now adduce such evidence as can be derived from geological or antiquarian discoveries, which apparently attest the contemporaneity of man with the Giant Deer.

The first instance, I believe, in which any trace of the works of man is recorded as having been found associated with the remains of the Megaceros, is given by Pownal, in the 3rd vol. of the Archæologia. This notice is only incidental, and therefore, I think, the more valuable. He states that in digging away the bog of Callen, in Tipperary, at about six feet deep, there were found trunks of trees, all of which were rotten, excepting those of the oak and fir, and some horns, large enough to have a circle of three feet in diameter, described on each palm; also some gold and other ornaments.

Dr. Leigh, gives several instances in which the horns of the Fossil Elk had been found in Lancashire and Cheshire, in bogs, and also that the whole head of an Hippopotamus had been found in the same position, together with a small mill-stone, or quern, beads of amber, an ancient brass vessel, and human bodies entire and uncorrupted, as to outward appearance.* In another place he states, that, on draining Marton Meer, eight canoes were found embedded in marl.† It does not appear that the horns and canoes were found in immediate contact, but still, not far distant; and if the canoes were actually embedded in the marl, then there is the presumption that the Elk and Hippopotamus were alike contemporary with the Celtic inhabitants of Britain.

Professor Goldfuss, of Bohn, records the discovery of the horns of the Megaceros in the Duchy of Cleves, and that urns and stone hatchets were found in the same place. Major Charles Hamilton Smith, in alluding to this discovery, says: —As these remains are found almost invariably in recent formations and vegetable mould, it would be more unreasonable to deny than give our assent to the opinion of Professor Goldfuss, that the destruction of this species may be of more recent date than is commonly supposed.

Amongst the bones presented to the Royal Dublin Society by Archdeacon Maunsell, was a rib, in which Dr. Hart, of Dublin, discovered an oval aperture near its lower edge, the long diameter of which was parallel to the length of the rib; its margin was depressed on the outer and raised on the inner surface, round which was an irregular effusion of callus. This opening, the Doctor conceived, was evidently produced by a sharp pointed instrument, which did not penetrate so deep as to cause the animal's death, but which remained fixed in the opening for some length of time afterwards. In fact, that such an effect would be produced by the head of an arrow remaining in the wound after the shaft was broken off; and from which he inferred therefore, that the chase of this gigantic animal once supplied the inhabitants of this country with food and clothing. The Doctor further observes—I am well aware of the occasional existence of holes in ribs, a few instances of which I have seen in the human subject; but they differ essentially in character from the opening just described in the rib of the Deer, as they occupy the centre of the rib at its sternal extremity, and have their margin depressed on both sides.

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* Phil. Trans., 1701, vol. xxii., p. 626.

† Jour. Dub. Geo. Soc., vol. i., p. 204.

Professor Owen, in combating the above theory, objects to its probability for the following reason :—That a conical arrow-head, with a base one inch in diameter, sticking in a rib with its point in the chest, must have pierced the contiguous viscera, and, rankling there, excited rapid and fatal inflammation. The evidence of the healing process in the bone would rather show that the instrument which pierced the rib had not been left there to impede the vis medicatrix naturæ. A pointed branch of the formidable antler is as well suited to inflict such a wound as the hypothetical arrow; and if the combative instincts of the rutting Stag rightly indicate the circumstance under which the wound of the Megaceros was inflicted, they would be those which best accord with the actual evidence of recovering from it.

Dr. Scouler, in alluding to the perforated rib, observes,—The combat of two males might cause the wound, and it is deserving of notice that in the very locality where the rib was found, two heads were also found with the antlers entwined in each other. The teeth of a carnivorous animal might also have caused the wound; and, finally, a wound from the branch of a tree while the animal was swimming might also cause the mark of violence which we perceive on the rib.

As far as my own observation goes, and from the appearance of the tynes of the horns of the Megaceros, they seem very unlikely to have produced the wound in question; and, as Mr. Richardson justly remarks,—The point of a tyne coming in contact with a surface so convex, so narrow, so smooth, and so elastic as that of a rib, would, instead of perforating, glide off, and pass between the ribs, penetrating the cavity behind them; or, if driven with such force as to avoid the slipping, it would not stop at making a hole, but would crush through all opposition and fracture the ribs; and, again, as velocity gives more perforating power to a blow, than actual force or weight, it is easier to imagine an arrow penetrating and sticking in a rib, than the most violent blow of a horn, which might be turned aside, should perforate the bone.

With reference to the remarks of Dr. Scouler, I conceive that the fact of the two heads being found with their horns entwined, although, perhaps, sufficient evidence that the animals died in mortal combat, does not necessarily prove that the rib in question had belonged to either of these individuals, as the bones are seldom found close to the head, (as I am informed,) and still more opposed to this having been the case, is the circumstance, that the wound in the rib was an old one. Again, that the wound had been made by the teeth of some carnivorous animal is, I think, exceedingly doubtful, for if the attack was made during the life-time of the Deer, the aperture would have been closed up by fresh bony matter, supposing the individual to have lived long enough for the natural restoration to take place; and, if not, the wound would have only presented the appearance of a recent perforation, while Dr. Hart expressly states that there was, round the hole, an irregular effusion of callus or new osseous substance, proving that the Deer survived the injury some time, and also that some foreign body intervened between the edges of the aperture, and remained there for a while. Again, I cannot conceive it possible for any animal to seize the rib of the Deer and make a horizontal perforation during the lifetime of the latter, as the rotundity of its body would render such an attack impracticable; while, on the other hand, after death, and when the parietes of the abdomen had been torn open, and its intestines protruding, the edges of the ribs could be readily seized between the teeth.

I have already stated that the bones of the Giant Deer are frequently discovered in the mounds of earth, called Raths or Danish forts, in Ireland; and I believe it is almost exclusively in such localities that they are associated with the implements of the former occupants of the soil; hence, it is presumed they were slaughtered by the latter, more especially, as the other bones found with them are all of animals used as food by man.

One of these mounds was opened by Hugh Palliser, Esq., at Castle Warden, in the county of Kildare; in which were found—a great variety of cooking implements, hatchets, knives, strange looking culinary utensils, charcoal ashes, large stones half roasted, together with quantities of spear and arrow heads, of combs, and bronze, iron, and bone skewers for holding the mantle; besides these were quantities of bones, from whence Mr. Palliser inferred that these raths were baking hearths, used to dry a supply of food for the consumption of the conquering invader, or the numerous retainers of the feudal chieftains; and when they had done with the bones they were thrown into natural or artificial valleys near the spot, to prevent their tainting the air. If they had come there by accident, why should we so frequently find heads by themselves, and the tynes of the horns invariably placed downwards? but we can readily imagine the reason when we admit of human agency.*

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* Richardson, p. 30.

The most minute account of a mound of this description, is that given by Mr. Wilde, in the 1st Vol. of the Royal Irish Academy's Reports, when recording the exhumation of a quantity of skulls and bones of Cattle, Deer, Goats, and Swine near the village of Dunshaughlin. At about ten miles from Limerick is a small lake called Lough Gûr, having in the middle an island with one of these forts; some time since, in consequence of a canal having been cut by the proprietor, the water was lowered many feet, which rendered visible a quantity of bones; these were so abundant that the tenants carted them to Limerick for shipment to London and Liverpool to be ground for manure; upon this island and in the surrounding lake, the bones of five species of Deer, including the Megaceros, five species of Oxen, the Goat, Swine, and several other smaller animals and birds; also swords, spear heads, and other implements of man, were found by Messrs. Glennon and Nolan, of Dublin. The skulls of the Cattle and Swine had large ragged fractures in the frontal bone exactly similar to those which appear in the skulls of Bullocks slaughtered at the present day with the pole-axe. There was no reason for doubting that the animals to which these skulls belonged had also met their death from the hands of man. Besides the above, however, were two reputed skulls of the female Gigantic Deer, which presented the same fractures, and were, consequently, supposed to have resulted from the same cause. This circumstance was announced in the *Dublin Evening Post*, for November 14, 1846, and as might be expected, created no little interest; for such an occurrence, if true, would undoubtedly settle the question as to the preadamite epoch of the Deer. These skulls were examined by Professor Owen and Dr. Ball, and pronounced to be those of males from which the horns had been forcibly torn off.

This assertion was as warmly opposed by Messrs. Richardson, Newman, and Glennon, who positively pronounced the skulls to be those of females, and also denied the possibility of the fractures in the frontal bone having been produced by the cause assigned, from their position in the first place, and secondly, from the fact that the female is destitute of horns.

Mr. Newman thus concludes his observations on the subject in the preface to the *Zoologist*,—At the first cursory glance it may appear somewhat strange that the skulls of the males should invariably have been found entire. I do not, however, find any difficulty here; in the first place, we may fairly suppose that the males, like our Bulls, were not equally prized for food; in the second place, the size, as well as the position of the antlers, would render it next to an impossibility to give the desired blow with the pole-axe; in the third place, the greater strength and thickness of the skull would, almost to a certainty, render the blow unavailing; and in the fourth place, supposing the females domesticated, and the occasional tenants of sheds and other buildings, we may well imagine that the males were excluded from such buildings by the enormous size of their antlers. Perhaps only the males were suffered to become adult. Perhaps the males were allowed free range, the females only being permitted at stated seasons to accompany them. In fine, the more we investigate probabilities—the more we reason from present experience and knowledge—the less difficulty shall we find in the way of believing the Gigantic Deer of Ireland an animal coeval with man and subservient to his uses.

Never having seen the skulls in question, I shall not presume to give an opinion; although it appears to me almost impossible for any one to confound the skulls of the male and female Deer, either perfect or fractured, who had seen both, the general form and size being so very distinct, more especially the enormous thickening of the frontal bone in the male, to enable the animal to sustain its immense antlers. And I may also observe, that if the position of the frontal perforation was really as described like those in the skulls of the short-horned Ox and Swine of which I possess specimens, I cannot conceive how any wrenching off the horns from the peduncles or temporal bone could by any possibility produce such an orifice, but would, on the contrary, entirely destroy and tear asunder the skull. I must, therefore, leave this important question as it now stands; not without, however, expressing a fear that many of these accounts are too highly coloured by the narrators,—whether purposely or not I will not say,—and, consequently, rather injure than support the theory they are intended to serve.

The Count de Salis, proprietor of Lough Gûr, informed Mr. Glennon that he had in his possession many spear heads, swords, and a brass dish, found on the Island; and Captain Roberts, of Sallymount, county of Kildare, informed Mr. Glennon, in 1846, that in removing the earth from one of these mounds or raths, in the summer of 1845, he found many bones and skulls of the Giant Deer, together with broken horns of the same animal, and the skull of a man.*

In the *Leeds Intelligencer*, (1854,) occurred the following paragraph, copied from an Irish paper:—

"DISCOVERY IN IRELAND.—Not long since, a large portion of a peat bog in the north of Ireland moved, leaving the bed quite bare; and on examining the bed afterwards, there were found the horns of an enormous Deer. On further examination of the district, there was also found a large mound, twenty or thirty feet in diameter, in which was a number of pens, made of oak in a very workmanlike manner; and in the centre was deposited a number of tools,—stone hatchets, and hammers. The pens contained skeletons of the Irish Elk, Ox, and other animals, which, from marks on the skulls, had evidently been killed by man. Shortly after this, there was found, beneath the stream, a perfect skeleton of a man, clothed in skins, the hair outside, with a pouch at his side and a belt round his waist. Although the skin was very much discoloured, the skeleton and flesh were perfect."

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* Zoologist, 1847, p. 1592.

My friend, Dr. Ball, of Dublin, however, thinks the mere association of human implements with the bones of the Deer is no proof of their having been contemporary, but thus accounts for the circumstance. With the ancient Irish, it was a well-known mode of fortification to build these Island forts in valleys, where a stream ran, surrounded by a stockade of wood, and he supposes they would commence operations by first driving down the wooden posts or paling; into this was then thrown earth from the ditch formed round the whole, together with the marl, accompanied by heads and bones of the Giant Deer; the workmen, however, wrenching off the horns to enable them to pack closer on the top of the mound, upon which a wooden castle was ultimately erected. In this would be collected various implements for the domestic or warlike use of the inmates, which would accidentally or otherwise accumulate in the ditch below. In course of time the castle fell by war, fire, or decay; and, finally, by the rotting of the original stockade, the mound would crumble and fall down, depositing the Elk bones and soil above the implements of human construction. Thus they would be eventually found associated, apparently furnishing conclusive evidence of their co-existence.

Mr. Richardson states in the *Zoologist*:—In a letter I have received from Mr. Benn, of Ballymena, occurs the following passage:—In the collection of the late Mr. Johnston, of Down, which has been left by his uncle, an attorney, and in which everything was labelled with the accuracy and precision of that profession, is a small brass spear, with a piece of wood still in the socket, with a label stating it to have been found in a marl pit, among the bones of a Deer.

In an able paper "On the Geology of the Isle of Man," read before the Geological Society of London, in 1845, by the Rev. J. G. Cumming, the author remarks:—Whether the human race inhabited the island at the time of the older alluvium, will admit of question; but the Elk, which, at any rate, was then existing, may have continued as an inhabitant of the hills at the time of the submergence of the lowlands, of which he resumed the occupancy when the final emergence subsequently took place, and those insular lakes were formed in which we find the remains of this singular animal associated with the implements of human art and industry, though of an uncouth and ancient character.*

Now, as I am not aware that any ancient erections like the Irish Forts have been discovered in the Isle of Man, some other cause must be assigned for the association of human implements and Mammalian remains, if they appertain to different periods, than the one of Dr. Ball, which will only apply to Ireland.

Besides these forts for defensive purposes, some examples of the habitations of the earliest settlers have been discovered. A wooden house, found under sixteen feet of bog, in the county of Donegal, has been described by Captain Mudge, which, though skilfully framed—mortised and grooved, was evidently the work of a people devoid of metal tools and implements, and who subsisted largely on hazel nuts for food. Now, the depth at which this dwelling-place was found, indicates its extreme antiquity; and if below the bog, it would be resting upon the marl, which is the situation of the bones of the Megaceros, and therefore most probably of the same date, and earlier than the forts, as they contain weapons and implements of metal.

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* Quarterly Journal of the Geological Society, 1846, p. 345.

In Kent's Hole, at Torquay, in Devonshire, in a bed of reddish sandy loam, vast quantities of fossil bones of extinct Bears, Hyænas, Tigers, as well as fragments of the horns of the Megaceros, &c., have been found beneath a bed of solid Stalagmite, intermingled with patches of charcoal, human bones, several flint knives, arrows, spear heads, and fragments of pottery, &c. The stone implements are of the kind usually found in early British tumuli, and doubtless belong to the same period; yet here they are mixed with bones of supposed immense antiquity, and beneath the impermeable and undisturbed floor of the Cavern. This discovery was supposed to present unequivocal proof that man and the extinct Carnivora were contemporary inhabitants of the dry land at the period when the ossiferous loam was deposited. Dr. Mantell, however, after describing the above appearances, did not think they warranted any such inference, but thus accounts for the mixture of human and Mammalian remains:—That Kent's Hole and Banwell Cave were mere fissures in the limestone rock, which have been filled with drift while submerged in shallow water, and into which the limbs and carcases of animals were floated by currents. Upon the emergence of the land, of which the raised beds of shingle afford proof, the fissures were elevated above the water, and gradually drained; the formation of Stalactites and Stalagmites from the percolation of water then commenced, and continued to a late period. If, when Kent's Hole first became accessible, and while the floor was in a soft and plastic state, and before the formation of the Stalactitic covering, some of the wandering British Aborigines prowled into the cave or occasionally sought shelter there, the occurrence of stone instruments, pottery, bones, &c., may be readily explained; for any hard or heavy substances, even if not buried, would quickly sink beneath the surface to a depth of a few feet, and afterwards become hermetically sealed up, as it were, by the crust of Stalagmite that now forms the solid pavement.*

Now, although this explanation of my late worthy friend may appear plausible at first sight, I really think it is untenable. I am ready to admit that part of it which illustrates the subsidence and emergence of the land, and that the remains of extinct animals may have been so drifted into the cavern; but why not the human remains also? Here we find an association of bones belonging to quadrupeds and man, with relics of human art, all deposited in one bed of loam, and all hermetically sealed over by one layer of Stalagmite; yet the bones of the animals are referred to one period, and those of man to another, and without, as it appears to me, a satisfactory explanation.

If we only admit the probability that man and the extinct animals of the superficial deposits at least were contemporary, all is clear and easy to comprehend. But the moment we reject this supposition, all becomes perplexing and obscure. In this instance, we must either admit that centuries elapsed from the extinction of the quadrupeds, the deposition of their carcases, and their subsequent emergence; or that their destruction and the subsequent elevation of the district, with their bones, was comparatively rapid. The former excludes the occurrence of man and his works in the same deposit with the bones of animals, and is also opposed to the comparatively slight accumulation of sedimentary material the fissures contain. The latter is contrary to the usual order of nature, if the destruction of the extinct races was brought about by physical causes alone.

If we allow, with Dr. Mantell, that the fissures of the rocks, already containing the bones of Mammalia, were gradually drained after emergence, then the mud must have been dried and hardened and Stalagmite formed before any inhabitants could have left their rude weapons in the caverns; as, be it remembered, none were previously in existence, which two facts of themselves are fatal to the Doctor's theory. For we must either conjecture that this event took place at a period long antecedent to the human epoch, or that man was already in existence upon one of the numerous small islands with which the primæval ocean was supposed to be studded, on the emergence of this portion of Britain. If the former supposition, then the deposit could not have remained in the soft and plastic state which the Doctor assumes for an indefinite lapse of time, until the creation of man, and his subsequent migration from the cradle of our species in the East to the British Isles, without the commencement of the stalagmitic covering, which would at once have placed a barrier between the human and quadrupedal remains; as centuries must have elapsed before the former event is likely to have occurred. And yet according to the Doctor's supposition this very covering was deposited subsequent to man's visiting the caves! With such conflicting theories, therefore, is it not more prudent to assume that all the remains were drifted in or deposited at the same period, and then equally covered with lime? Such a theory appears to be borne out by the evidence of Mr. Vivian, who, in a paper on this subject, read before the British Association in 1847, says:—After taking every precaution by sweeping the surface and examining most minutely whether there were any traces of the floor having been previously disturbed we broke through the solid Stalagmite in three different parts of the cavern, and in each instance found flint knives closely resembling the rudest of those found in the most ancient barrows. The nearest spot at which flint is found, is Aller, about five miles distant. The thickness of the Stalagmite is about two feet. In the spot where the most highly finished specimens were found the passage was so low that it was extremely difficult with quarrymen's tools and good workmen to break the crust; and the supposition that it had been previously disturbed is impossible in an age when no metal appears to have been in use, and the spot was about 400 feet from the entrance.*

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* Archæological Journal, vol. vii., p. 341.

Dr. Mantell, in his last work,† in speaking of the Megaceros says,—Remains of this majestic animal have been found collocated with ancient sepulchral urns, stone implements, and rude single trunk canoes, in such manner as to leave no doubt that this now extinct species was coeval with the Aborigines of these Islands.

Professor Anstead, in alluding to the occurrence of human remains with those of extinct animals, remarks, "It would certainly be unsafe to assent in the face of the evidence that exists, that man has not really been an inhabitant of the earth for a much longer time than historic records seem to show."‡ And in this opinion I perfectly coincide, for if we go no further than our own islands it does not appear that we have even positive testimony when and from whence Britain was first peopled, though there is every probability that it took place at a much earlier period than is generally supposed. For the learned Retzius has shown that the earliest inhabitants of Ireland, of whose skulls remains still exist, were identical in ethnological character with the Lapps of the present day. Now it is a remarkable coincidence that remains of the Rein-deer, as I have already stated, have also been found in Ireland, and that the human bodies which have been discovered in bogs were clothed in the precise clothing of the Lapps, also of the present day,—skins and coarse woollen garments. How these Northmen with their Rein-deer became located in such a distant spot I shall not presume to explain, though the theory I have previously suggested of Ireland having originally formed part of a large continent, may afford some clue, as upon such a supposition a colony of that people might wander with their herds to this extreme point of land, and settle there and finally become isolated by the gradual submergence of what now forms the bed of the Irish Channel and North Sea, or some narrow tract of land which connected them with the north of Europe. May not the occurrence of the Bear and Wolf in Britain, both, natives of the colder parts of northern Europe at the present day, also strengthen the above conjecture, and which may in like manner have wandered westward in pursuit of the Rein-deer, Megaceri, and other ruminating animals?

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* Report of the British Association, 1847, p. 73.

† Petrifactions and their Teachings, p. 456.

‡ Elementary Course on Mineralogy and Geology, page 314.

I have already said that the age of the Megaceros will necessarily involve that of other quadrupeds whose remains are found in the same situations, and are universally admitted to have been its contemporaries, as the Mammoth Rhinoceros, Hippopotamus, &c., in this country, and the Mastodon in America, whose period of existence is supposed to date very early in the earth's history, or at least to an epoch anterior to man. That it has this effect I allow; but this is no valid objection, unless we had positive evidence of the precise periods when the above large Pachyderms lived and ceased to live, which I venture to suspect we have not. In the last work published, which touches upon this subject by one of our most practical geologists, my esteemed friend Professor Phillips, he declares his belief that these very quadrupeds ceased to exist in the glacial epoch, an opinion which he doubtless considered was supported by geological evidence, and which he had arrived at by cautious induction. Yet while this very work was passing through the press, a most important discovery was made in the brick clay of the Aire valley deposit near Leeds, of the remains of the Hippopotamus, the Mammoth, and of the Urus; and as this deposit is evidently of post glacial date, it is in direct opposition to the theory of Professor Phillips; and in addition to this fact, they were apparently associated with the works of man. Such disclosures, therefore, show us plainly that, even in geology, we have much to learn as well as to unlearn, and how necessary it is to be open to conviction, even when opposed to generally received theories.

The theory which I am endeavouring to establish is simply this:—That when we find the bones of extinct animals of a supposed remote period associated with those of Molluscous animals of genera or species equally extinct, it is perfectly logical to suppose that all are of the same age, from the fact that all have shared the same fate, and alike ceased to exist! When again we find the remains of animals also extinct, but of genera well known, associated with those of animals still living and indigenous to Britain, and also with mollusca and plants still common in the district,—Is it not equally logical to reason that these are also of the same age? And further, if we find the skeletons of some of these extinct animals with portions of their integuments, as skin, and hair, still adhering to their bones,—the contents of their stomachs undestroyed,—or their remains associated with the works of man,—does it not suggest a reasonable doubt whether the life periods of such animals may not be less ancient than is generally attributed to them? and from such instances which have occurred in various places, I shall adduce a few well authenticated examples in support of my position.

In 1715, in digging for the foundation for a mill near the side of a brook, at Maghery, within eight miles of Bulturbet, the bones of a Mammoth were found lying four feet beneath the surface on a bed of stiff blue clay, covered over with ferns, rushes, branches of trees, and nut shells. The clay divided into layers, between each of which the seeds of the rushes occurred as fresh as if new pulled, from whence it was inferred the animal had been destroyed in the height of seed time or towards the end of summer. The fronds of the fern were also very distinguishable, as also the tops of the boughs. The whole mass smelt very sour as it was dug, and occupied a space 34 feet by 20 or 22.*

In 1772, Pallas obtained from Wiljuiskoi, in lat. 64, the carcase of a Rhinoceros, taken from a frozen sandbank. The body still retaining its corpulency was covered with its skin resembling leather, which emitted an odour like putrid flesh; part of the skin was still covered with black and grey hairs, the eyelids and eyelashes still comparatively perfect. The head and one foot of this animal are now in the Imperial Museum at St. Petersburg.

In 1806, the entire carcase of a Mammoth was obtained by Mr. Adams from a mass of ice in the mouth of the Lena, in lat. 70; the flesh of which was so well preserved that it was devoured by the Bears, Wolves, Foxes, and other animals while it lay exposed on the bank. One of its ears was entire, and furnished with a tuft of hair; the pupil of the eye was still to be distinguished, the lower lip had been gnawed by animals, the upper one was entirely gone, and the teeth exposed. The brain was still in the cranium, though apparently dried up; and the animal, which was a male, with a long mane on its neck, appeared so fat, according to the Tungusian hunters, that its abdomen hung down below the joints of its knees. The skin of this animal, which required ten people to carry, was thickly covered with reddish wool and coarse long black hair, from 10 to 16 inches long, 36 lbs. of which was gathered from the wet sand bank where it was trodden in by the wild animals while devouring its flesh. The skeleton, which now adorns the Museum at St. Petersburgh, is 9 feet in height, 16 in length, without its tusks, which alone measured 9 feet 6 inches, and weighed 360 lbs. A small portion of the skin with the hair upon it, is now in the College of Surgeons, London, and when first received still retained an offensive smell; a small quantity of the hair and wool is also in the Museum of the Yorkshire Philosophical Society.

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* Philosophical Transactions, 1715, vol. vi., p. 199.

In October, 1844, the Skeletons of five Mastodons, four mature and a calf, were exhumed on a farm near New Jersey, in the United States. The largest lay on its side, and a few feet further lay the next in size on its back, a little to the north and west occurred the other two and the calf, all in a standing position; between the ribs of two or three of them was a considerable quantity of what resembled coarse chopped straw, probably grass mixed with fragments of sticks, all of which were no doubt the contents of their stomachs. The number of individuals occurring together, and most of them in a standing position, seemed to indicate they had been overwhelmed in one of their native haunts by some sudden catastrophe, and this at no very remote period.*

In the summer of 1845, the Skeleton of an immense Mastodon was exhumed about six miles west of Newburgh, United States, which was entire even to the small bones of the feet and tail. The skull alone weighed 700 lbs.; the tusks measuring nine feet, and the width across the hips seven feet. The animal had evidently settled down on its haunches with its fore feet spread out, thus indicating that it had been mired, and hence the cause of its death; under the vertebræ the contents of the stomach were found, which amounted to several bushels, and consisted of leaves, twigs, and fragments of branches, crunched and broken up.†

In 1847, Professor Gray exhibited to the Boston Natural History Society, some earthy matter filled with broken fragments of branches of trees found occupying the place of the stomach of a skeleton of the Mastodon, exhumed on Schooley Mountain. Professor Gray stated that the wood consisted of branchlets of one, two, or three years old, broken uniformly into bits of half an inch or more in length, with only now and then a trace of the bark remaining. The wood was not fossilised, and but slightly decayed, and from its general appearance he inferred it belonged to some coniferous tree, probably a kind of spruce. This supposition he subsequently confirmed by the examination of thin slices under the microscope, which exhibited beautifully and distinctly the circular disks that characterise coniferous wood, and perfectly agreed with similar portions from the hemlock spruce, a tree still common in the district. The great interest of this announcement of Professor Gray's, consists in his being able to ascertain what plants the Mastodon had actually last been feeding upon.*

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* Meeting of the American Philosophical Society, December, 1844.

† Geological Journal, 1845, page 567.

The fine skeleton of the Mastodon now in the British Museum, was found in the State of Missouri, imbedded in a brown sandy deposit full of vegetables, amongst which could be recognised the cypress, tropical cane, swamp moss, and palmetto; and Mr. Koch, the late proprietor and discoverer, personally assured Dr. Mantell that an Indian flint arrowhead was found beneath the leg bones, and similar weapons were imbedded in the same soil, which he took out with his own hands.†

Sir Charles Lyell, in his travels in America, states that he saw at Genisco the skull, tusks, and vertebræ of a Mastodon, dug out of a bed of shell marl and sand, the shells being all existing fresh water and land species, now common in that district;‡ and it is evident, he adds, that at a comparatively recent period, since the Atlantic was inhabited by the existing species of marine testacea, there was an upheaving and laying dry of the bed of the ocean in this region. The new land supported forests in which the Megatherium, Mylodon, Mastodon, Mammoth, a species of horse, different from the common one, and other quadrupeds lived, and were occasionally buried in swamps.* At Big-bone Lick, in Kentucky alone, the bones of not less than one hundred Mastodons, and Mammoths, besides those of the Stag, Horse, Megalonyx, and Bison, have been obtained from black marl containing recent terrestial and fresh-water shells; and it is impossible to view this plain without at once concluding that it has remained unchanged in all its principal features from the period when the extinct quadrupeds inhabited the banks of the Ohio and its tributaries.†

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* Edinburgh New Philosophical Journal, xliii, p. 184. † Mantell's Fossils in the British Museum, 473. ‡ Travels in North America, vol. i., p. 55.

In 1820, an entire skeleton of the great Mastodon was found in a marl pit at Horstead, near Norwich, lying on its side, stretched out on the surface of the marl, beneath the gravel, and, from the statement of the pitmen, when first discovered, was very soft, and could have been "spread like butter," the muscular portion of the animal having been converted into adipocere.‡ Now, although the Mastodons are generally allowed to have lived in a preceding age to the Mammoth, as their remains are never found associated with the latter, still the fact here recorded, taken in connexion with those just enumerated as having occurred in America, justifies the supposition that the termination of the Mastodon epoch is less ancient than is generally supposed.

Mr. Strickland found, with the bones of the Hippopotamus at Burfield, in Essex, twenty-four species of land and fresh-water shells, nineteen of which are still living in the neighbourhood, proving that no very material change has taken place in the climate, or physical geography of the district of the former.

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* Travels in North America, vol. i., page 164. † Vol. ii., p. 65.

‡ Fairhome's Geology of Scripture, p. 281.

Cuvier states, in his Ossemens Fossiles,—That in excavating the canal of Ourcq, near Sevran, in the Forest of Bondi, the remains of the Megaceros were found, with portions of trees, in precisely the same place as the bones of Elephants (Mammoths,) consequently proving them to be equally recent, which fact is also pointed out by Professor Owen, who says that,—The evidence of the former existence in England of the Gigantic Irish Deer, contemporary with the Mammoth, Rhinoceros, and other extinct Mammalia of the period of the formation of the newest tertiary fresh-water fossiliferous strata is complete.*

In 1853, in the same bed of clay, at Wortley, near Leeds, in which occurred the bones of four specimens of the Hippopotamus, and also the Mammoth and Urus, was found an earthen vessel of unbaked clay, without any external markings whatever, also a fragment of pottery with a distinct pattern on its surface, and glazed; near to these was a large circular block of grit stone, in the centre of which was a hole still containing a piece of iron. The upper surface of the stone was marked with circles, apparently caused by the friction of some other body revolving upon it. This had probably belonged to a quern, and, with the other remains of human construction, apparently attests their contemporaneity.

The Red Deer, or at least a Deer which, as Professor Owen says, is undistinguishable by its enduring remains, from that species, co-existed with the Megaceros, the Spelæan Hyæna, the Rhinoceros, and the Mammoth, and has survived, as a species, those influences which appear to have caused the extinction of its gigantic associates. In Cambridgeshire, part of the horn of a Red Deer was found near to a portion of the skull of the Mammoth, under a stratum of clay, underlying peat moss. In October, 1844, antlers and various bones of the Red Deer and short-horned Ox were found near the city of Worcester, associated with Roman pottery, hazel nuts, and trees. Horns of the Red Deer, with Roman and British antiquities, were found in the superficial deposits at Selsey and Bracklesham. Antlers and bones of the Red Deer were found associated with remains of the Mammoth and Rhinoceros in the fresh-water deposits at Brentford and Rugby, in the valley of the Thames, and that of the Severn. On the coast of Yorkshire, the remains of the Megaceros have been found in a submarine peat, containing trees with nuts, with bones of Oxen, Red and Fallow Deer.* Now, as the Red Deer and Rein-deer still exist in Europe, is it unreasonable to conceive that the Giant Deer may also have lived, as Mr. Newman observes, until the human era commenced, and might still exist were it not for the intervention of man himself? The absence of historical records so long before the invention of printing is of little avail on this point, as the same argument might be employed to show that the round towers of Ireland, of which nothing positive is known, were equally pre-adamite with her Deer.

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* Owen's British Fossil Mammals, p. 468.

Therefore, with such facts before me as I have just cited, although I am willing to concede to geologists that the life-periods of the extinct Pachyderms and large Ruminants date at an early period in the history of our planet, still I conceive it is neither unphilosophical nor unwise to endeavour to ascertain whether they did not actually exist much nearer the present time than is usually supposed, even within the human era. From a conviction that in no science more than in geology is it necessary to use the utmost caution, both in deducing new theories as also retaining too tenaciously long cherished opinions, from the fact that in no science has such extraordinary revelations taken place within the last half century as in geology. I cannot forget that, less than forty years ago, it was considered heresy to suppose that any animal remains higher in the scale than the Mollusca were to be found beneath the Lias. When no Mammalian remains were allowed to occur lower than the Upper Tertiary, or Calcaire Grossier, and when the Quadrumana, or Monkeys, were not even supposed to have been called into existence! What, however, is now the fact? Not only have above two hundred species of fishes been found in the various strata extending down to and even in the Old Red Sandstone, but Reptilian remains also have been satisfactorily demonstrated in the Coal itself. The Marsupialia have been detected in the Stonesfield slate, and Monkeys, as large as any now existing, in the Eocene formations. Surely then, such revelations as these, in direct opposition to supposed fundamental doctrines, ought to teach us the useful, though humiliating lesson, that it is wiser to withhold judgment than to draw too rigidly the exact line or period when certain animals ceased to exist, and also, whether Man was or was not also their associate. For, in the elegant language of Sir C. Lyell, I would observe,—The recent progress of discovery in our science puts us upon our guard against founding hasty generalisations on mere negative evidence, and warns us against the presumption of taking for granted that our present knowledge of the earliest occurrence of a particular class of fossils in stratified rocks can be reasoned upon as if it afforded a true indication of the first appearance of a particular class of beings on the globe.*

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* Phillips's Geology of Yorkshire.

Finally, then, in my endeavour to trace the Megaceros down to the human era, I am by no means advocating the idea that they have, as species, been equally long inhabitants of this earth. On the contrary, I suppose that the last stragglers *only*, which escaped annihilation by physical changes and causes, may have continued to exist down to Man's first appearance on the British Isles; and as precisely similar views regarding the extinction of the Dinornis in New Zealand have been advocated by Dr. Mantell in one of his last communications to the Geological Society, I shall make no apology in concluding with his remarks when speaking of the Moa-beds:—Both these ossiferous deposits, though but of yesterday in geological history, are of immense antiquity in relation to the human inhabitants of the country. I believe that ages, ere the advent of the Maoris, New Zealand was densely peopled by the stupendous bipeds whose fossil remains are the sole indications of their former existence. That the *last* of the species was exterminated by human agency, like the Dodo and Solitaire of the Mauritius, and the Gigantic Elk of Ireland, there can be no doubt; but, ere man began the work of destruction, it is not unphilosophical to assume that physical revolutions, inducing great changes in the relative distribution of the land and water in the South Pacific Ocean, may have so circumscribed the geographical limits of the Dinornis and Palapteryx, as to produce conditions that tended to diminish their numbers preparatory to their final annihilation.

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* Address to the Geological Society, February, 1850.

In the absence of James Nasmyth, Esq., C.E., of Patricroft, Manchester, Mr. Durden read that gentleman's communication

ON A NEW SYSTEM OF PUDDLING IRON BY STEAM.

In order to render the object and nature of this invention more clearly understood, it will be as well to describe and explain the nature and object of the process in the Iron Manufacture termed "puddling," or the process whereby cast iron is converted into malleable iron.

The difference between cast iron and malleable or wrought iron, is chiefly due to the presence in the former of a considerable quantity of carbon in combination with the iron. In order, therefore, to convert cast iron into malleable iron, it is requisite that we remove or drive off the carbon from the cast iron. This object is effected by exposing the surface of a quantity of molten cast iron as it lies in that state on the bottom of a suitable reverberatory furnace, to the action of a current of heated air, so that the oxygen of the air, as it passes over the surface of the molten cast iron, may combine with the carbon and carry it off in the form of carbonic acid and carbonic oxide gases.

But as the naturally tranquil surface of the molten cast iron would not present sufficient surface of metal to the action of the air drawn over it by the draft of the furnace, and would, if left in a tranquil state, require a very long time to elapse ere the carbon was by the action of the air abstracted from the cast iron, it is found requisite to agitate the metal, so as to continually expose fresh surfaces to the decarbonising action of the air.

This agitation is effected by raking the molten metal backward and forward by an iron rake or paddle called a "rabble," worked by the attendant at the furnace, who puddles amongst the molten iron with his rake to effect the agitation required—hence the term "puddling." As these iron rabbles have to be made of considerable strength and weight, and as the iron through which it is moved is somewhat stiff, although in a fluid state, the labour of this process of puddling is excessive, and it has in the ordinary system to be continued without interruption for upwards of thirty-five to forty minutes, the workman being all the while exposed to the violent heat of the surface of the furnace, distant only three to four feet from his person.

After the carbon has been sufficiently carried off by the oxygen of the air, the molten cast iron becomes stiff and pasty, losing its fluidity, and shortly exhibits a granular condition caused by the accumulation of particles of malleable iron which collect together and are made up into "balls" by the workman, who, by means of a suitable iron paddle, presses these granulated particles into larger masses within the furnace, from whence they are in due time removed, and beat and rolled into bars by aid of hammer and rolls.

Now, having given this description of the process of puddling and its object, I shall proceed to describe the nature of my improvement: which simply consists in employing the combined mechanical and chemical action of steam, to effect at one and the same time the effects for which such a vast amount of manual labour is required, in the ordinary mode of agitating or puddling the iron by hand, so as to enable the air passing over the surface of the iron to remove or abstract the carbon.

In order to accomplish the desired object, I introduce a current of steam beneath the surface of the molten cast iron, by means of a curved iron steam pipe, so that when the steam is let on, and the orifice of this pipe is depressed down to the bottom of the pool of molten cast iron, the steam, in passing up through the molten iron, not only throws the metal into violent agitation, but also by reason of the intimate contact of the steam with the molten iron, the steam is decomposed, the liberated oxygen passing to the carbon of the cast iron with which it combines, and passes off in the condition of carbonic acid and carbonic oxide gases; while, the hydrogen liberated at the same time, combines with another portion of the carbon of the cast iron, forming carbureted hydrogen, and another portion of the hydrogen unites with any sulphur which the iron may contain, and removes it in the form of sulphuretted hydrogen.

In order to enable the operator to cause the steam to act equally on all portions of the molten iron, the steam pipe is made with a flexible joint, so that the submerged orifice of the steam pipe may be moved about within the furnace, and the current of steam made to pass up through the molten iron at any part of the basin. Such, however, is the energetic action of the steam in agitating the molten metal by its passage up through it, that a very gentle action of the steam pipe suffices to cause every particle of the iron to be subjected to the decarbonising and desulphurising action of the decomposed steam.

Such is the extraordinary ease and rapidity with which we are enabled to decarbonise the cast iron by the introduction of a current of steam up through the molten iron, that in four to five minutes from the time of introducing the steam pipe beneath the surface of the molten cast iron, its conversion into malleable iron is effected; thirty-five to forty minutes being required on the old system.

No special alteration in the furnace is required, and about 50s. will provide the requisite steam pipe. The submerged end of the steam pipe gets coated over with the cast iron, but the waste of it is very slight, and as it is only the submerged end that does waste, that part is made removable. Each end lasts fully eight to ten days, and only costs 9d each time it is removed.

The introduction of steam with the puddling furnace has before been made the subject of patents; but no success attended the application until I introduced the steam up through the molten iron by means of a submerged moveable pipe in the manner above described.

Messrs. Rushton and Eccersley, of Bolton, have now twelve puddling furnaces in constant action by my steam system, and yielding first-rate iron.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FORTY-FOURTH (THE ANNUAL) MEETING, HELD IN THE PHILOSOPHICAL HALL, LEEDS, ON THURSDAY, DEC. 13TH, 1855.

Henry Briggs, Esq., Outwood Hall, having been called to the Chair, said that he regretted the smallness of the audience, but hoped that the excellence of the papers would compensate for the paucity of hearers. Thomas Wilson, Esq., V.P., of Leeds, was, he said, to have presided; but he had been unexpectedly called from town. The first part of the proceedings would be of a business character, and he should call upon the Secretary to read the financial statement.

Mr. **Ward** read the cash account, and then observed that he regretted he had not a more favourable report to present, but he was happy to say the Society could be carried on with very little expense. The small attendance might be accounted for, from the fact that there was to be an Evening Meeting, which would, no doubt, be better attended.

STATEMENT OF RECEIPTS AND EXPENDITURE

Of The Geological and Polytechnic Society of the West Riding of Yorkshire.

From November 8th, 1854, to December 13th, 1855.

DR.	£.	s.	d.
By Balance in Treasurer's hands....	15	10	2
,, Balance in Mr. Battman's hands	8	8	6
,, Subscriptions—			
From 7 Members for 1853	4	11	0
,, 55 ,, 1854	35	15	0
,, 35 ,, 1855	22	15	0
,, 1 ,, 1856	0	13	0
,, Donation from the Mayor of Halifax	1	0	0
,, Mr. Ward for 50 Copies of his Paper	0	7	0
	£88	19	8

CR.	£.	s.	d.
To Collecting Subscriptions	2	5	0
,, Postages	0	19	4
,, Rent of Museum, 1 year..	20	0	0
,, Messrs. Baines, on Account	20	0	0
,, Advertising Meetings	1	12	10
,, Expenses of Meetings	3	2	0
,, Assistant Secretary	25	0	0
,, Stationery	0	3	0
,, Sundries, Parcels, &c.	0	15	4
,, Balance in Treasurer's hands....	6	13	8
,, Balance in Mr. Battman's hands	8	8	6
	£88	19	8

LIABILITIES.	£.	s.	d.
Messrs. Baines......................	31	13	8
Philosophical Hall, half-year's rent	10	0	0
Salary of Assistant Secretary, for 1½ year.........................	75	0	0
Palæontographical Society....	1	1	0
Commission to Mr. Battman	4	8	6
	£112	3	2

ASSETS.	£	s.	d.
Cash in Treasurer's hands	6	13	8
Cash in Mr. Battman's hands	8	8	6
Arrears of Subscriptions due	63	4	0
	£78	6	2

E. MAUDE, Esq., Chapeltown; JOHN HAIGH, Esq., Honley, near Huddersfield; and Mr. H. C. MORTON, of Leeds, having been elected Members; Mr. EDDISON nominated the following Officers and Council for the ensuing year, which were adopted:—

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

THE DUKE OF NORFOLK.
THE EARL OF EFFINGHAM.
THE EARL OF DARTMOUTH.
LORD WHARNCLIFFE.
VISCOUNT MILTON.
RT. HON. SIR C. WOOD, BART.
T. W. BEAUMONT, ESQ.
E. B. DENISON, ESQ., M.P.
J. S. STANHOPE, ESQ.
GODFREY WENTWORTH, ESQ.
J. G. MARSHALL, ESQ.
MICHAEL ELLISON, ESQ.
R. M. MILNES, ESQ., M.P.
VISCOUNT GALWAY.
WILLIAM BECKETT, ESQ., M.P.
REV. WILLIAM THORP.
THOMAS WILSON, ESQ.
JOHN WATERHOUSE, ESQ., F.R.S.
EDWARD AKROYD, ESQ.

Council.

HENRY BRIGGS, ESQ.
DR. WM. ALEXANDER.
T. W. EMBLETON, ESQ.
H. C. SORBY, ESQ.
MICHAEL STOCKS, ESQ.
JNO. JEBSON, ESQ.
HENRY HOLT, ESQ.
CHARLES MORTON, ESQ.
THOMAS PITT, ESQ.
BENJAMIN BIRAM, ESQ.
DR. WILLIAM PALEY.
R. CARTER, ESQ.

Honorary Secretary.

WILLIAM SYKES WARD, ESQ.

Honorary Curators.

T. W. EMBLETON, ESQ. | J. G. MARSHALL, ESQ.

Auditors.

BENJAMIN BIRAM, ESQ. | G. W. CHAMBERS, ESQ.

Local Treasurers and Secretaries.

DR. ALEXANDER, Halifax. | H. C. SORBY, ESQ., Sheffield.
HENRY BRIGGS, Esq., Wakefield. | R. D. BAXTER, ESQ., Doncaster.

Mr. ARMYTAGE was then called upon to explain the Model (upon the table) of Messrs. Robinson and Co.'s Smoke Consuming Furnace, which he briefly described as follows:—That the usual construction of furnaces is to pass the smoke over the bridge of the boiler by an up draught into the flue, and thence to the chimney; Mr. Armytage said in this mode a down draught was obtained, and smoke and the other gases had to pass through their own fire, and were thus consumed. The fire box contained two grates, the upper one of which is formed of hollow tubes, connected at one end with the boiler, and at the other with a waterspace in front, through which the water continually and rapidly circulates; this upper grate alone is fired, and employing a down draught or current of air, admitted through the upper doors, the gases, smoke, &c., from the green coal, when put on, pass through this fire downwards, and whatever may escape is consumed by coming in contact with the upward flame from the lower grate. This low grate, formed of ordinary rocking bars, is entirely fed by the half-consumed coal, or cinders falling through the upper tube grate; and the fire from this low grate burning upwards, its flame meets the downward fire from the upper grate and passes through the flues in the ordinary way. The second range of larger tubes is put in for additional heating surface. The construction of the furnace is varied according to form and size of boilers, and its advantages are:—Effectual consumption of smoke—more rapid and increased generation of steam—and at least 25 to 30 per cent. saving in fuel. If the smoke was not perfectly consumed in passing through its own fire, the residue would be consumed in the space between the lower and upper grate.

An interesting discussion ensued, in which Mr. Watson, Mr. Eddison, Mr. Ward, Mr. Carter, and others took part; during which, Mr. Armytage explained the cost of applying the apparatus, and of the patent right, and stated that no coals would clinker on the upper grates. In reply to the Chairman, he said they had had the apparatus in operation ten months; but they were not able to say whether there was any liability of the tubes becoming stopped from the deposit from the water. There was, however, so rapid a circulation through the tubes, that they did not think there would be any deposit. In reply to Mr. Swale, he stated that the apparatus could only be applied to steam boilers.

Mr. Eddison said that the apparatus was admitted on all hands to be effective, but was there no apprehension of danger from the bursting of the tubes?

Mr. ARMYTAGE replied that the tubes were guaranteed at 500 lbs. pressure to the square inch, but in order to test this question, they had violently broken a tube in the centre with a chisel, whilst there was a pressure of 30 lbs. the inch on the boiler, and the only result was, that the fire was put out, and then all danger ceased. He also added that the apparatus had met with the approval of practical men generally, and Mr. W. Fairbairn's manager had told him that some boilers they were making for Mr. Salt, at Saltaire, and which were fitted with this apparatus, would bear a pressure of 100 lbs. the square inch. In reply to Mr. Carter, he said there was no necessity for high chimneys, but if they did away with the chimney, they must have a fan to create a draught.

The CHAIRMAN, alluding to the opinion entertained by some, that the consumption of smoke was only a questionable benefit, as the increased generation of carbonic acid gas neutralised the apparent benefit, said he believed that there was as much carbonic acid gas evolved where the smoke was not consumed, as where it was.

Mr. WARD made some observations with reference to the chemical process of combustion, and expressed his opinion that this apparatus was fully adapted to all the requirements of the case. As to carbonic acid gas, the public were under a complete mistake as to its being a deleterious gas. It was entirely neutral in its operations when pure, and from 20 to 25 per cent. in the atmosphere might be breathed without injury; but one per cent. of carbonic oxide would be extremely poisonous, and the latter was often confounded with the former. As to vegetation, carbonic acid gas was a benefit, but they did not find their vegetation improved by smoke from long chimneys, and the question arose as to whether the gas evolved was not carbonic oxide. He did not, however, apprehend much detriment from carbonic oxide, as its specific gravity was such that it would rise into the atmosphere rather than descend.

The CHAIRMAN said that the injury to vegetation did not arise from carbonic acid or carbonic oxide, but from the sulphurous gases, which could not be got rid of.

Mr. WARD expressed his dissent from this view, and said he believed the injury to the plants arose from the deposit of solid carbon, which stopped the pores of the leaves. As to the mechanical part of the question, he thought there was no danger from the bursting of the tubes, as tubes of locomotives were continually bursting without any material injury resulting. He thought if there was any weakness, it was in the absence of sufficient stays in the fire box, according to the sections on the patentees' circular.

R. C. Carter, Esq., C.E., Halifax, read the next paper, entitled—

OBSERVATIONS ON A NEW BORING MACHINE FOR ARTESIAN WELLS, AND OTHER PURPOSES.

Mr. Carter commenced by observing that Earth-boring having become a matter of considerable importance in relation to objects of public utility and private enterprise, any improvements in the art of boring—especially of artesian wells—was peculiarly interesting and valuable. The machine of which he had to speak was that of Messrs. Mather and Platt, engineers, Salford, the chief novelties of which were the construction of the boring head and shell pump, and the mode of acquiring the percussive motion. Mr. Carter explained the principle of the machine by the aid of an admirable model placed upon the table; of which a full description, with figures, of the apparatus is given in the "Journal of the Society of Arts" for June 1, 1855. He spoke in the highest terms of its successful results, as tested in various kinds of soil and rock, whether looked upon with regard to expedition, efficiency, or economy; and he added that it afforded nearly the same facilities for boring 1,000 feet deep as it did at a depth of only 100 feet.

The Chairman, who said that he had had some experience in boring, expressed his warm approval of this machine, which was a very great improvement upon any method of boring he had ever seen before.

Mr. Carter, in reply to a question, said that the machine could be worked with a portable engine, which would be found sufficient for the purpose.

The Chairman said that in the ordinary rod-boring, the cost was increased every ten yards; but in this principle of rope-boring, the difference of expense in regard to depth was very trifling: that was one of the advantages of this machine; and another was, that the machine brought up large portions of earth at a time, and enabled them to judge of the stratum in which they were working, in a way and to an extent that had never before been accomplished.

Mr. Carter, in reply to Mr. Eddison, said that he regarded the machine as calculated to work a complete revolution in the mode of supplying water to large towns. After a few other remarks, during which the Chairman alluded to the importance of the papers which had been read that morning, a vote of thanks was given to Mr. Carter, and the meeting adjourned till evening.

At the Evening Meeting, Mr. E. H. Durden was called to the chair, when Mr. W. S. Ward, the Hon. Sec., gave a *résumé* of the papers which had occupied the morning meeting, for the benefit of those persons who were not present at the reading of those communications. He next read a valuable statistical paper—

ON THE SUPPLY OF SHELLS, HORNS, BONES, AND WOODS USED IN THE CUTLERY TRADES OF SHEFFIELD, COMMUNICATED BY WM. FISHER, JUN., ESQ., OF SHEFFIELD.

The employment of ivory in cutlery having been treated of by others, the first substance used in hafting cutlery to which I should ask your attention is mother-of-pearl. This beautiful and durable material is largely imported into England from the coasts of the South American, Indian, and Chinese seas; but the only nacreous shells possessing sufficient thickness for Sheffield purposes, are received from Manilla and Singapore. The smaller shells from Bombay, Panama, and other ports are used chiefly in Birmingham, and are there worked into buttons, or used for inlaying purposes. The Manilla and Singapore fisheries produce annually from 300 to 400 tons of shell, most of which is sent to this country. The consumption here, however, I should estimate at somewhat below 100 tons per annum—the rest of the import is used for the best Birmingham goods or exported to the continent. The present value is now about £130 to £140 per ton; but the supply and demand is so variable that Manilla and Singapore shell has been sold within the last fifty years at almost all rates between £60 and £600 per ton. These shells are in Sheffield cut into scales and handles by circular saws, and the pieces have afterwards to be ground down on stones singly and by hand, to a level surface and a required thickness. This tedious process aids in making this a costly covering for cutlery, and as the substance is both hard and brittle, when the handles or scales are fluted or carved, the price is of course still more enhanced. Commencing with the statistics of the Horn trade, I shall have to estimate the supply of foreign horns, as since 1847 I find no record of the imports and clearances of these articles. When they were chargeable with duty, all sorts were classed together, and from 1843 to 1847 the imports ranged from 1,600 to 2,700 tons per annum, and averaged 2,250 tons. The clearances for home consumption varied from 1,200 to 2,200 tons per annum, and averaged 1,600 tons. I estimate that the subsequent clearances for home use have been fully equal to that average, and that 1,400 tons per annum are worked up in this town. Of the Ox and Cow Horn but little is used for cutlery purposes, nearly all the hollow portion is cut into suitable lengths, opened, flattened by heat and pressure, and worked into combs or lanthorn leaves. The solid point is used for knife and umbrella handles, and the hollow parts of such horns as are mottled with grey or black and white, are used for penknife scales, hollow parts that are not particularly well-suited for combs, being pressed into scales for sword or razor handles. The imports of Horns are large from South America (one million annually), the Cape of Good Hope, Australia, and other parts. The home produce is also very considerable. Assuming that the population of London is 5½ times that of Liverpool, and that there is a proportionate slaughter of oxen, the horns produced by the London slaughter would exceed in count 388,000 per annum, and the value, with the slough that fills the hollow part, would at present exceed £40,000. The pith or slough that fills the horn is crushed for tillage or boiled for sizing in the clothing districts. Horns vary in value from 20s. to 100s. per 123, and have been 50 per cent. above these rates.

Buffalo Horns are imported from Calcutta, Bombay, Siam, and Madras, and I suppose that some 350 tons are worked-up in Sheffield annually. Buffalo Horns are sold by weight and are at present worth from £15 to £30 per ton — the count runs from 700 to 2,000 to the ton, and taking the average at 1,400, the mortality among Buffalos in the East required to supply our Sheffield needs will be about 245,000 per annum. I should imagine the export of this article to the continent is nearly equal to the consumption here; and as there is also a considerable import of tips or solid points of horns, 800,000 to a million Buffalos each year must die in India, to account for the horns and tips brought to England from thence. The horns are here sawn by circular or hand saws into suitable lengths, boiled and cut by a sweigh knife, the hollow parts into pieces suitable to be pressed into scales, and the solid parts into pieces suited for pressing into knife or umbrella handles. These are the chief uses of Buffalo Horns, but some parts are used for dressing combs. Snuff boxes, drawer handles, miniature frames, stirrups, and many other articles are also pressed from Buffalo Horn. The waste from Buffalo and Ox Horns, Tips, and Hooves, when light and thin, is used as tillage, but the heavier portion has of late years become more valuable to burn for Prussian blue. For this purpose its present value is £5 to £6 per ton; and I am informed by a collector that about ten tons' weight is produced weekly in Sheffield. This appears a large weight; but a very considerable proportion of waste is produced in working horn, and the waste from the makers of buttons from cattle hoofs is no doubt included in the estimate. Of Ox, Cow, and Buffalo Horn Tips, I suppose 350 tons per annum are used in Sheffield, in addition to those from the horns cut in the town, these are chiefly pressed; but such of the Ox and Cow Tips as are sound and richly mottled are called self-tips, and are worked to the required shape by the circular saw and the file. The heat requisite for pressing them would damage the colour, and pressed horn being much more liable to run out of shape with use, self-tip handles make a much more durable handle than pressed horn, and have a very superior appearance.

The import of Stag and Deer Horns is probably about 450 tons per annum, and this import is exclusively for Sheffield. The chief supply is from the East Indies: and from Colombo (in Ceylon), Calcutta, Bombay, and Madras 350 to 400 tons per annum are shipped. The remaining supply is received from Germany, Italy, Southern Russia, Spain, and Norway. The German is the most esteemed, and it is worth from £100 to £180 per ton. The supply from that country lessens each year as the forests decrease and the native cutlery manufacture extends. The present value of Indian Stag Horn is from £30 to £50 per ton. Some years ago it was £65 to £80. Stag Horn is sawn into scales and handles by circular and hand saws, and the waste pieces are boiled for sizing in the cloth-making districts. With the exception of the Elk (not yet extinct in Germany, and having the heaviest of horns), the Deer tribe have horns heavy and solid in proportion to the heat of the climate in which they are produced. The horns dropped on the hills and plains of Hindostan and Ceylon are very heavy and almost as solid as bone. From Southern Russia we have Deer horns lighter than the Indian but heavier than the German, and the Rein-deer Horn from Norway and Lapland is much lighter and more pithy than the German. It is, however, much less valuable as the surface is white and quite smooth. Its value is not more than £15 to £21 per ton. Taking the import from India at but 350 tons, and the average weight at 1,400 per ton, it appears that the "fall" (as it is termed) from 240,000 head of Deer is annually collected in India for Sheffield uses. Very few manufacturers cut their own Stag Horn; it is chiefly cut up by horn cutters who supply cutlers with handles and scales.

The Bones cut here for cutlery purposes are chiefly those extending from the knee to the hoof of the Ox. In London these bones are carefully boiled by the neat's foot oil makers, and by this process the colour is so improved that in common cutlery bone handles (for the forks) are often used as ivory. From 600,700 to 700,000 is about the supply Sheffield receives annually from London, and the value is 15s. to 18s. per hundred. The consumption for cutlery will probably be 400,000 or 450,000, the remainder being used for button moulds. The supply of bones from the country districts I have no means of ascertaining, as they are chiefly brought by hawkers of pots, &c., and pass direct into the hands of the bone cutters. As to the extent of supply from abroad, I am also at a loss, as the returns do not distinguish between tillage bones and such as are suited for manufacture. The total import of both classes is about 30,000 tons per annum. The tillage bones are worth from 130s. to 140s. or £6 to £7 per ton, and others £8 to £17.

Tortoise Shell is now little used for cutlery, and of what is so used part is merely the scrap shell from combmakers. I dare say that not above 1,000 lbs. weight of plate shell is at present used in Sheffield for knife scales. The present value of West Indian shell is 18s. to 25s. per lb., and Manilla 25s. to 38s. or 40s.

When ladies vied with each other as to who should have the largest comb, the value of the best was 50s. to 63s. per lb.

The chief woods used for cutlery purposes are Cocus, from Cuba and Jamaica, and Ebony, from Africa and the East Indies; there is also a consumption of Bar, Partridge, Pheasant, Beech, and Yew woods, for cutlery purposes, and 400 or 500 tons per annum will be about the average consumption of these woods.

Of the extent to which cutlery is made with silver, silver-plated, porcelain, iron, or pressed wood handles, I am entirely ignorant. The following, to the best of my judgment, is a fair summary of the value of raw materials with which I am acquainted that are used for knife handles and scales:—

		£.		£.
90	Tons of Ivory, averaged at...	500	per Ton	45,000
100	,, Mother-of-Pearl	130	,,	13,000
350	,, Buffalo Horns	20	,,	7,000
250	,, Tips	25	,,	6,250
350	,, East India Stag Horn ..	40	,,	14,000
50	,, German, Spanish, and Italian......................	100	,,	5,000
1000	Lbs. Tortoise Shell at.........	25s.	per lb.	1,250
400,000	London Bones of 120, at ...	18s.	per 120	3,000
	Foreign and country Bones, say about ...			4,000
450	Tons Cocus, Ebony, and other woods	£8	per Ton	3,600
	Total..................			£102,700

The value of the labour expended in working these materials into handles or scales is very various,—in some instances, as in pressed handles, it is greater than that of the raw material; in others, as in plain ivory handles, it is much less.

The last communication for the meeting was a verbal description by Mr. Ward, of the "Collodio-Albumen Photographic process, as applicable for copying Mechanical and Scientific Objects." It was announced that the next quarterly meeting would be held in Sheffield, early in March, 1856.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-FIFTH MEETING, HELD IN THE
CUTLER'S HALL, SHEFFIELD, ON WEDNESDAY, JULY 30TH, 1856,
AT TWELVE O'CLOCK AT NOON.

THOMAS DUNN, Esq., in the Chair.

The following noblemen and gentlemen were elected members :—

His Grace the Duke of Norfolk.
His Grace the Duke of Leeds.
The Right Hon. Lord Wharncliffe.
Viscount Goderich, M.P.
E. F. Sanderson, Esq., Sheffield.
G. S. Beecroft, Esq., Abbey House, Kirkstall.
J. O. Butler, Esq., Kirkstall.
W. Chadwick, Esq., Arksey, Doncaster.
T. P. Teale, Esq., F.L.S., Leeds.

The CHAIRMAN called upon Mr. SORBY, of Sheffield, to read the first paper :—

ON THE ORIGIN OF THE CLEVELAND HILL IRONSTONE.

BY H. C. SORBY, ESQ., F.G.S.

The investigation of the circumstances that have given rise to the various rocks that are met with, constitutes a branch of Geology of considerable interest. It has too frequently been supposed that stratified rocks were accumulated in a form far more like what they are now, than is warranted by a more careful enquiry ; and this has, in many cases, led to the conclusion that the conditions under which they were found, were unlike those occurring at the present period; whereas they may, perhaps, have been exactly the same, and the difference in the aspect of the rock brought about by a subsequent change of the same nature as must also now take place in many localities. The case before us is an example of this. The Cleveland Hill Ironstone, now so extensively worked at Eston, near Middlesbro', is composed, to a very great extent, of carbonate of iron, and yet it can scarcely be supposed that such a deposit could be formed in any modern sea; because, owing to the strong affinity of the protoxide for oxygen, it would be accumulated as the peroxide. Besides this, I am not aware that there is any sea in which any great amount, even of this, is now deposited, except with a very considerable quantity of other substances mixed with it; its chief source being the decomposition of such silicates as the augite and hornblende of various traps and hornblendic schists, which, in some cases, would yield a clay containing one-third of its weight of this oxide.

If the stone be carefully examined, it may be seen that it contains more or less entire portions of shells. In some cases these are still of their original composition, and consist of carbonate of lime, but in others they are changed to carbonate of iron; the difference being apparently due, in some instances at least, to the kind of shell. The microscopical investigation of a thin transparent section of the stone shows far more clearly that the minute fragments of shell have been similarly altered; the replacing carbonate of iron extending, as yellowish obtuse rhombic crystals, from the outside to a variable distance inwards, often leaving the centre in its original condition, as clear colourless carbonate of lime, though in many instances the whole is changed. The oolitic grains likewise, have such peculiarities as indicate that they were altered after deposition.

In order to illustrate this fact of the replacement of carbonate of lime by carbonate of iron, I subjoin an analysis of a shell from the inferior oolite of Robin Hood's Bay, the composition of which, as dried at the ordinary temperature, I found to be:—

Carbonate of protoxide of iron	78.0
,, lime	5.2
,, magnesia	3.1
Peroxide of iron	10.9
Water	2.1
Carbonaceous matter	0.1
Quartz substances	0.6
	100.0

Originally, such a shell would be composed almost entirely of carbonate of lime, with only a small quantity of other mineral substances, and no iron; but, as will be seen, it is now almost entirely carbonate of iron, with some hydrous peroxide, no doubt due to the action of the atmosphere. The peculiarities in microscopical structure, already described, prove that the same change has occurred in the case of a large proportion of the constituents of the Cleveland Hill Ironstone; and, according to the view I propose to explain its general constitution, all that is assumed is that it did also in a similar manner affect the more finely grained particles, which do not, and could not present such facts as actually prove it to have been so, and yet would be more perfectly exposed to such a process of alteration. The general appearance of the stone agrees remarkably well with this supposition; for, when examined with the microscope, it is seen to be extremely like many limestones in all such particulars as are compatible with the subsequent alteration, being oolite, with small fragments of shells and patches of finer granular matter, as is the case in many oolitic limestones.

I will not enter into a detailed description of its chemical composition, for that has been so ably treated of by others. I would especially refer to the excellent analysis published on the Iron Ores of Great Britain, part I., of the Memoirs of the Geological Survey. On comparing together the amounts of the various constituents there given, it may be seen that the rock consists chiefly of the carbonate and some of the silicate and phosphate of the protoxide of iron, along with a much smaller quantity of the carbonate of lime and magnesia, and some alumina and peroxide of iron. Independent, then, of the silica and alumina resulting from the clay so commonly found in limestones, and the phosphate of iron, the general composition is very similar to that of the altered shell already described; so that, as far as the chemical composition is concerned, the same circumstances that *must* have altered the shell, *may* have changed an ordinary limestone into such a rock, in the manner indicated by the microscopical structure to have really been the case.

The silicate and phosphate of iron, to which the rock owes its green colour, have been most probably formed by the same process, from the decomposition of the phosphate of lime, so often found in limestones, and the silicate of alumina of the clay; for phosphate of iron is produced by the action of bicarbonate of iron on phosphate of lime, and many facts indicate that the silicate of iron could be thus derived, either by the direct replacement of the alumina of the clay by the protoxide of iron, or by the decomposition of silicate of lime. This does occur in some limestones, and may have been formed from ordinary clay by the action of the sulphate or hydrate of lime, which are met with in the recent limestones of coral reefs.

The general conclusion that I therefore draw from these facts is, that, at first, the Cleveland Hill Ironstone was a kind of oolitic limestone, interstratified with ordinary clays containing a large amount of the oxides of iron, and also organic matter, which, by their mutual re-action, gave rise to a solution of bicarbonate of iron—that this solution percolated through the limestone, and, removing a large part of the carbonate of lime by solution, left in its place carbonate of iron; and not that the rock was formed as a simple deposit at the bottom of the sea.

ON THE PURIFICATION OF LEAD BY CRYSTALLIZATION. BY WILLIAM BAKER, ESQ., OF SHEFFIELD.

The following Paper is to shew chiefly that copper may be separated from lead by the process of crystallization introduced in 1833, by Hugh Lee Pattinson, for the purpose of desilverizing lead, which process is now very generally employed in England and on the continent.

Pattinson was led to this discovery by the accidental upsetting of a pot containing argentiferous lead, which had cooled down nearly to the point of solidification. Observing a portion more fluid than the rest; he found upon assaying both, that it contained the larger proportion of silver.

The principles of the process are these:—When lead containing a certain amount of silver is melted and then allowed to cool slowly, whilst it is constantly stirred, a crystallization of pure lead obtains at a temperature at which an alloy of silver and lead still remains fluid. The crystals of lead which sink towards the bottom of the vessel may be removed by means of a perforated ladle, leaving the rich lead, (that is lead containing an alloy of silver and lead,) to be further treated in a similar manner until the silver is concentrated sufficiently to be recovered by the old method of cupellation.

Formerly, lead containing less than 20 oz. of silver per ton would hardly bear the cost of extraction. By Pattinson's process, with a sufficiently extensive battery of pots, lead containing only 2½ to 3 oz. per ton, may be worked with advantage, as the metal, during the process, becomes softer and finer in quality from the removal of other foreign matters.

As an example of the purification of lead by this method, the following is a description of the results of some experiments made with a battery of four pots. The pots contained about six tons of lead. The metal employed being at the commencement, of very fair quality, as the accompanying analysis will shew:—

IN 100 PARTS.

	No. 1.	No. 2.
Copper	000.0066	000.0154
Iron	000.0065	000.0068
Silver	000.0046	000.0052
Sulphur	Trace	Trace

The iron pots are set in brickwork, and rest upon a broad rim, the fire playing freely round the hemisphere. Dampers are provided to regulate the temperature, upon which the success of the process much depends. The lead is melted as rapidly as convenient, the temperature being far below red heat. Constant stirring facilitates the separation of impurities which rise to the surface, and are removed by skimming with the portion of oxidised lead. The impurities thus removed, will be the easily oxidisable metals when present, as iron, antimony, arsenic, together with sulphide of lead. After skimming, the fires are raked out and the lead allowed to cool. It is kept constantly stirred, and any portions which solidify round the edge of the pan are sliced off with the iron tool used in stirring, and thrust into the fluid metal. In about an hour-and-a-half or two hours time, small crystals of lead are formed, presenting a granular appearance in the melted mass. These are removed to the adjoining pot by means of a perforated ladle. The temperature then is carefully preserved at the same point until a sufficient fraction has been taken out; the bottoms, or enriched portion, is ladled into another pan.

We may assume that it is only the pure lead which possesses this tendency to crystallize, and that the silver or copper found in every sample of the crystals is really only contained in the fluid alloy, entangled, so to speak, amongst the crystals. This will be readily granted on consideration of the imperfect separation of the solid and fluid particles obtained by simple draining in a perforated ladle.

Pursuing the operation in this manner, we obtain on the one hand, crystals increasing in purity and freedom from foreign metals; on the other, lead increasing in richness of silver and (as will be shewn,) of copper.

The fracture and other physical qualities of such kinds of lead present marked differences. As the crystals are purer, they are darker in appearance; those from the rich pot being sometimes of a silvery whiteness.

Annexed is a tabular view of a series of analysis which will at once shew that a similar law regulates the separation of copper as of silver from lead; that is to say:—there is an alloy of copper and lead which remains fluid at a temperature at which crystals of pure lead are formed. Iron, it will be seen, cannot be removed by this method, but is chiefly separated by oxidation, and subsequent skimming the surface of melted metal:—

In 100 Parts.

	Rich Pot.	Silver.	Copper.	Iron.
1	Before Crystallizing	.0108	.0344	.0312
2	Crystals—25 parts	.0052	.0152	.0086
3	Fluid Lead—85 parts	.0140	.0476	.0122
	Second Pot.			
4	Before Crystallizing	.0052	.0154	.0068
5	Crystals—95 parts	.0020	.0066	.0118
6	Fluid Lead—25 parts	.0126	.0286	.0146
	Third Pot.			
7	Before Crystallizing	.0020	.0102	.0118
8	Crystals—70 parts	.0010	.0038	.0198
9	Fluid Lead—25 parts	.0100	.0240	.0082
	Fourth Pot.			
10	Refined Lead	.0014	.0054	.0112

By the first crystallization, from .0108 per cent. 3 oz. 10 dwts. 13 grs. per ton Silver, is reduced to .0052 per cent. 1 oz. 13 dwts. 23 grs. per ton in the crystals; and concentrated to .0140 per cent. 4 oz. 11 dwts. 11 grs. per ton in the fluid lead, left in the pot.

Copper, from 11 oz. 4 dwts. 16 grs. per ton, is reduced to 4 oz. 19 dwts. 7 grs. in the crystals, and concentrated to 15 oz. 10 dwts. 23 grs. in the fluid lead.

In the second crystallization, the separation is still more apparent, as a larger proportion of crystals are removed than in the first. Ultimately, the Silver is reduced to only 9 dwts. 3 grs. per ton; Copper, 1 oz. 15 dwts. 6 grs. per ton in the refined lead.

It will be seen that the amount of foreign metals in the crystals should correspond to that in the metal of the next pot before crystallizing, and in most cases it is identical in others sufficiently near to prove the truth of the analysis.

Although iron appears in the first crystallization to be removed in a similar manner, yet, upon repeating the operation, it does not diminish in quantity in the crystals, nor become concentrated in the fluid lead, but rather the minimum seems to be in the samples of lead taken before crystallization, that is immediately after skimming. Contact with the iron vessels and ladles then supplies the increased per centage in the crystals.

It is probable that this method of purification succeeds best when the amount of impurities is not very considerable. For, in the instance of lead containing a large proportion of copper, when it is submitted to a regulated temperature just sufficient to melt the more fusible metal; it liquates, leaving a skeleton of copper. Upon this, a process is founded, called the liquation process, totally different from that described in this paper.

Thus, by melting at a regulated temperature, by skimming, and by crystallization, a lead may be obtained practically pure.

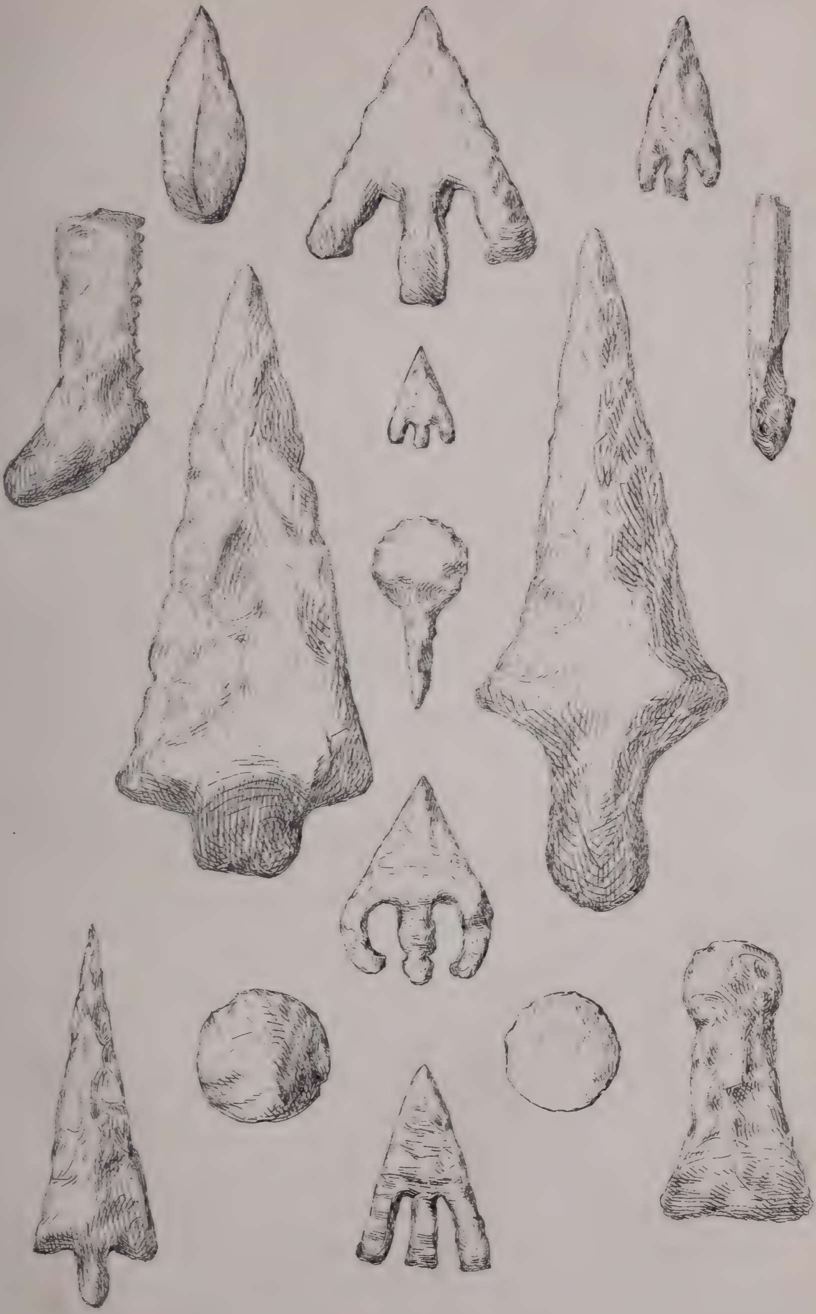
ON THE REMAINS OF A PRIMITIVE PEOPLE IN THE SOUTH-EAST CORNER OF YORKSHIRE; WITH SOME REMARKS ON THE EARLY ETHNOLOGY OF BRITAIN. BY THOMAS WRIGHT, ESQ., M.A., F.S.A., &C., CORRESPONDING MEMBER OF THE IMPERIAL INSTITUTE OF FRANCE.

On the southern part of the coast of Yorkshire, there is a tract of country secluded by its natural features from the other parts of the county. From the coast on the north, the wild elevated district of the Wolds makes a sweep out in a south-westerly direction, until it descends into the district now called Holderness; over which, formerly, thick and extensive forests and morasses stretched towards the south-east, to the mouth of the Humber. The Wolds must have been in early times almost uninhabitable, the forest forming a continuous line of barrier, resting at each extremity upon the sea. In the small district included within this barrier, the geographer Ptolemy places a tribe called the Παρίσοι, who dwelt περὶ τὸν εὐλίμενον κόλπον, round the well-havened bay, which, I have no doubt, we must identify with the present bay of Bridlington. Ptolemy has been quoted as further giving to this tribe a capital town, named Petuaria; but to me the language of the ancient geographer does not seem to countenance such a statement, and I think that we must take Petuaria as a town coming next after the territory of the Parisi, and probably situated on the banks of the Humber. A not improbable suggestion has been made by our modern ethnologists, that the name of the tribe, Parisi, is only a corruption of that of Frisii, or rather that the two words represent the same original name, and that the primitive people who dwelt round the bay of Bridlington were originally settlers from the opposite coasts of Friesland. I mention this suggestion as being rather a happy one, for it seems agreeable to what we might expect in such a tribe so situated; but at the same time I would urge how extremely cautious we ought to be in accepting arguments founded on, I fear, too often fanciful derivations of the old names of places and peoples, ascribed to languages of which we really know nothing, and which, sometimes, have existed only in the imaginations of those to whom we owe the derivations.

It is probable enough, from its physical character, that the district thus described remained in primitive simplicity long after the other parts of the island had made great advances in civilisation. During a recent visit, I have ascertained facts which leave no doubt that it was occupied by the Romans, though I can discover no reason for believing that they had any important station here. Indeed, I have at this moment in my possession Roman coins which I am assured were dug up at Bridlington; and I have an authenticated statement by Mr. Cape of that town, of the discovery, a few years ago, of the remains of a Roman villa, in the parish of Rudstone, a place well known to antiquaries by the upright stone in its churchyard, which probably dates from at least as far back as the Roman period, and which, perhaps, marks the head seat of the tribe. At a later period, Flamborough became celebrated as the landing-place of Ida, the leader of the Northumbrian Angles; and this particular district appears to have fallen to the lot of one of the families, or septs, of the settlers, which bore the name of Bridlingas, and who fixed their head-quarters at the spot called from that circumstance Bridlinga-tun, i. e., the mansion of the Bridlingas, a name which has been but slightly softened down in the modern Bridlington. During the whole of the earlier Saxon period, this country appears to have lost nothing of its secluded and almost inaccessible character. The Wolds to the north-west remained as wild as ever, while in the forest to the south of them, which was known as the Derawald, (a name that may be interpreted either the wood of the Deiri, or the wood of wild animals,) the solitude was so great that the little river of Hull, which passed through it, was celebrated for its numerous beavers, an animal which is known to avoid the haunts of men. One spot, probably an open place in the forest, which was known by the name of Befor-leag, or the field of beavers, was chosen as late as the latter end of the seventh century, by Archbishop John, on account of its solitude, for the establishment of a religious house, which was afterwards famous as the Abbey of Beverley. Indications of the earliest Anglo-Saxon settlers in this district are not wanting, for a Saxon cemetery of the pagan period has been met with in the immediate neighbourhood of the Roman villa already mentioned.

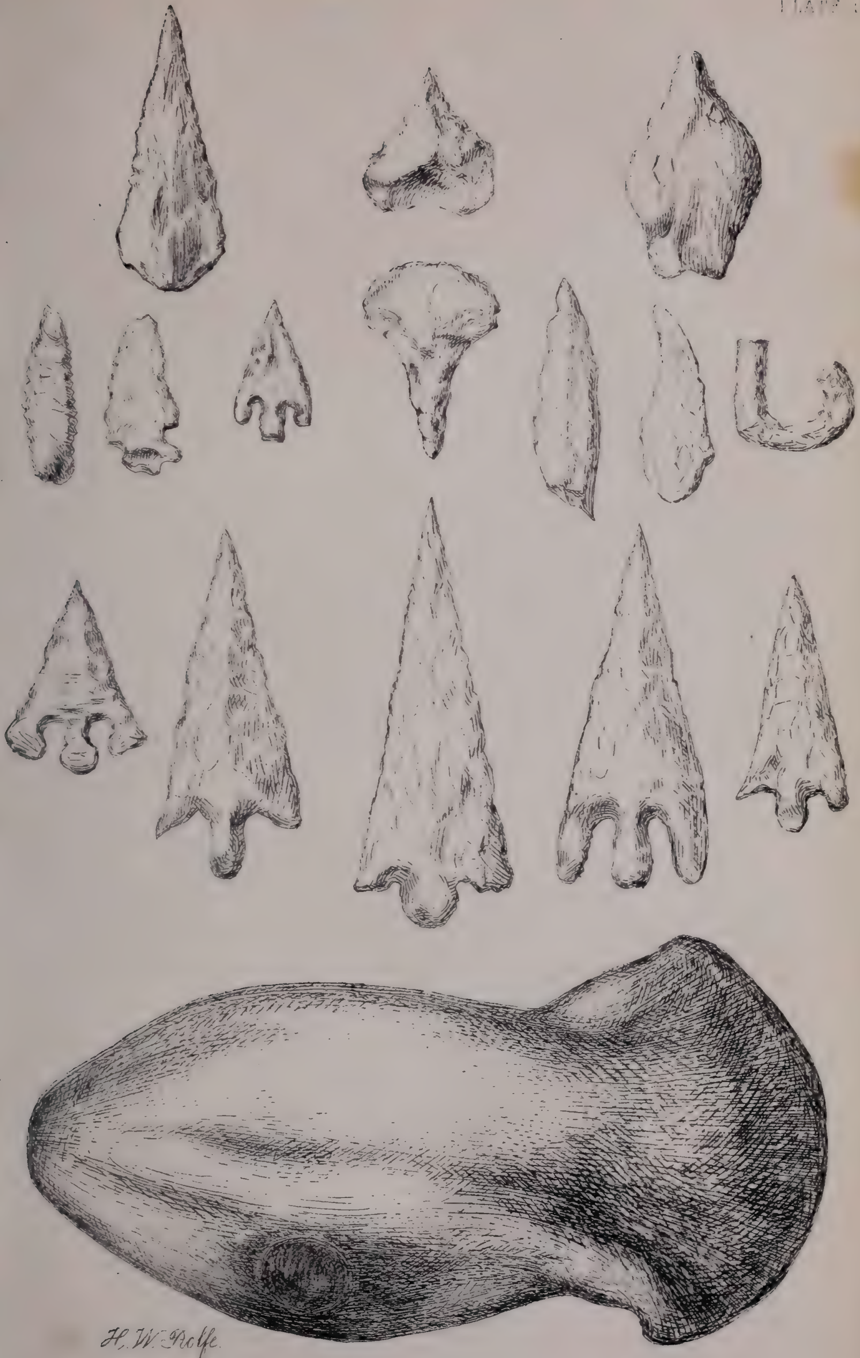
The traces of Romans or Saxons are, however, very trifling in comparison with the numerous examples of another description of objects which are found scattered over the whole of this district. These are implements of various kinds made of chipped flint, among which the most common are arrow-heads, with others of similar form but of larger size, which probably served for small spears or javelins. A large and very interesting collection of these curious implements has been made by Mr. Edward Tindall, of Bridlington; and Mr. Thomas Cape, of the same town, possesses, also, a considerable number, all found in that immediate neighbourhood by himself. Among them are observed fish-hooks, so delicately formed that we cannot but feel astonished at the labour it must have required to chip them out of a piece of flint. Nor is the accuracy with which the barbed arrow-heads are formed less surprising. I am inclined to think that some of the latter, from the sharpness of the barb, and from the middle spike being notched, as though for the purpose of being tied to a line, may have been intended also to serve as fish-hooks. Others appear to have been designed to serve as tools, knives, chisels, &c. We have examples, also, of flints finely and regularly notched on the edge, as though for saws; and one or two instruments which appear to have been intended for boring. A fine stone axe was found by Mr. Cape, at Lissett, between Bridlington and Driffield. Flat circular pieces of flint, about the size of a half-crown, are also rather common, and present all the appearance of having been intended to be thrown with a sling, or with a stick.

A comparison of these implements at once impresses us with the notion that they belonged to a people whose life was simple and uncultivated. They evidently supported themselves upon fish, which were caught with the hook, and upon birds and wild animals, which they shot with arrows, or struck down with rounded flints thrown from slings. Mr. Tindall informs me that the arrow-heads, and heads of spears or javelins, are found most abundantly in old moor-land on the sides of rather steep hills; and that when such land is first broken up and tilled, they are sometimes found scattered about in considerable numbers. It is evident that they belonged to a tribe confined within this district, because they appear not to be found beyond it. Mr. Tindall further informs me, from his own experience, that the sling-stones are found chiefly in and around Flamborough; that in the neighbourhood of Sewerby, about three miles from Flamborough, the rudest of the arrow-heads are found; and that, as far as his own observation goes, those of more perfect make are found furthest inland. This circumstance may be quite accidental, and is probably to be explained by the abundance or peculiar character of the game which frequented particular spots. We should naturally expect to find more of it on the edges of the Wolds, and on the borders of the forests, than near the shore; but the cliffs about and above Flamborough have from time immemorial been celebrated for the immense number of wild-fowl which resort to them, and



FLINT IMPLEMENTS FROM BRIDLINGTON

PLATE [illegible]



[illegible] LEMENTS AND STONE AXE FROM BRIDLINGTON.

for the slaughter of which the sling would, perhaps, be the most useful implement.

Another circumstance must be mentioned with regard to the localities in which these flint instruments are found. It appears that in particular fields in the immediate neighbourhood of Bridlington, they are met with in much greater quantities than in other places—in such quantities, indeed, that I am assured that a person who looks for them can hardly, at any time, walk across one of these particular fields without picking up one or two implements of chipped flint. I must, in connection with this part of the subject, call your attention to other pieces of flint, which are evidently, in some cases, the chippings from the flints out of which the other implements have been made, or the rough beginnings of implements which were either spoilt in the making, or were never completed. These seem to prove that the implements I have been describing were made in the district where they were used. I understand that these fragments and imperfect implements are found chiefly in these same fields to which I have just alluded, and I am, therefore, led irresistibly to the conclusion that these spots are the sites of establishments of people whose occupation it was to make the objects in question, and that these fragments, &c., are the refuse of their workshops (if we may apply such a term to them,) mixed, perhaps, with the remains of their stock, when they may have been obliged to leave the place through hostile invasion, or for other reasons at which we cannot now even guess.

To whom, we may ask, do these curious implements belong? I think, when we consider the locality, their primitive character, and the other circumstances of the case, we can have no hesitation in ascribing them to the same people whom Ptolemy places in this very spot under the name of Parisi; and I believe that they belong to a period extending from a limit which we have no means of fixing down, perhaps, to the time of the Anglo-Saxon invasion, or even it may be to a rather later period; though I should be inclined to ascribe the great mass of them to a date not later than the period of the Roman occupation. Thus from these few flints, gathered in the fields, we are enabled to add some important knowledge to the bare testimony of the ancient geographer; and we may now venture to state that the Parisi were a small tribe inhabiting the district round the bay of Bridlington, separated by the natural features of the country from the inland districts, living peaceably and very rudely on the produce of fishing and the chase, who were little, if at all, acquainted with the use of metals, or of any of the improvements of civilization; and, probably, they were few in number. We have as yet, no facts to enable us to say whether they were a fragment of an early Celtic population remaining in primitive ignorance, while their brethren in the interior advanced towards refinement; or whether they were some rude fisher tribe whom boats and the accidents of the sea had brought from Scandinavia, or from the opposite shores of the continent of Europe, to settle on this distant coast. Further observation may show whether remains, with very similar characteristics, are found on the coasts of northern Europe, and whether we find remains indicating a similar population, under similar circumstances, in other parts of the coast of our own island. I would merely observe, that it is a fact which must not be overlooked, that the tribe of the Parisi, though small, must have possessed some peculiarity distinctive from the tribes around, to entitle it to separate mention in the geography of Ptolemy.

This particular subject, or rather this particular case of an important subject, leads us naturally to consider that subject in its more general form, and I seize the opportunity for offering a few remarks on the ante-Roman ethnology of Britain. It is a subject which has been singularly obscured by baseless theories and speculations, arising out of the ignorance and prejudice of writers who have treated upon it in anything but a carefully scientific spirit. It is a subject on which the ethnologist has need of the co-operation of the archæologist; and yet, in this country at least, archæology is a younger *science* than ethnology itself. Both are, I fear, too much exposed to the two great dangers of a love for theoretic speculation on the one hand, and a tendency to generalise too hastily on the other.

In the geography of Ptolemy, we see our island distributed among numerous tribes, differing much in name, and differing also in the extent of their territories. Cæsar, the first who describes the island from personal observation and inquiry on the spot, tells us that the interior of the island was inhabited by people who were said, by tradition, to be the indigenous race, but that the sea coasts were occupied by Belgian settlers. We learn further, from his account, that there was in his time a wide difference in the degree of civilization between these midland aborigines and the inhabitants of the maritime settlements. Cæsar assures us that the Belgæ on the continent were mostly of German blood, *(plerosque Belgas esse ortos ab Germanis,)* and that they had crossed the Rhine to settle in districts from which they had expelled the Gauls. In another place he tells us that the Belgæ of his time differed as much from the Gauls in language and manners, as the Gauls themselves differed from the Aquitani, which we know was an entire difference of race and language. Without wishing to enter, at present, on a much debated question, I would remark that Cæsar's statements amount to a declaration of facts, which do not seem to me to be overruled by the theory of modern ethnologists; and

I am inclined to believe that at least a considerable portion of the population on the eastern and south-eastern coast of Britain, at the earliest period with which we are acquainted with it, was really of Teutonic origin. The account given by Tacitus at a somewhat later period, I think countenances this view of the subject, and he expressly points out physical characteristics in the Caledonians of the north which bespoke their German descent. All these are facts which I think are not shaken by speculative inductions. It seems evident, indeed, that at the earliest period at which we can hope to gain any information on the ethnology of our island, it was inhabited by a number of different tribes, differing in manners and in civilization, and of different race—in fact, that Britain had afforded a home for colonies at different periods, from the whole line of coasts stretching from the Baltic to the Bay of Biscay; and that it was not occupied by a uniform population which passed uniformly through different grades of civilization.

In fact, uniformity of condition, among the population of an extensive district of varied country, can only exist either in a state of absolute barbarism, where there is no intellectual development at all, or in the very highest degree of civilization, where inter-communication is general and extremely rapid. Yet it is on the implied assumption of some such uniformity that the antiquaries of Denmark have built their system of *periods*. "We are now," says Mr. Worsaae, from whose manual of Danish Antiquities I take the expression of this theory, "we are now enabled to pronounce with certainty, that our antiquities belonging to the times of paganism may be referred to three chief classes, referable to three distinct *periods*. The first class includes all antiquarian objects formed of *stone*, respecting which we must assume that they appertain to the *stone-period*, as it is called, that is, to a period when the use of metals was in a great measure unknown. The second class comprises the oldest metallic objects; these, however, were not as yet composed of iron, but of a peculiar mixture of metals, copper and a small portion of tin melted together, to which the name of bronze has been given; from which circumstance the period in which this substance was commonly used has been named the *bronze-period*. Finally, all objects appertaining to the period when iron was generally known and employed, are included in the third class, and belong to the *iron-period*."

Such is the system adopted by the antiquaries of the north, and which has been rather hastily accepted by some of our own writers on antiquarian subjects. It is ingenious, and has, no doubt, something attractive about it; but I believe it to be unnatural as well as un-historical, and I think it may easily be shown that it is even contradicted by facts. I ascribe this erroneous classification, first, to too great a tendency of the northern antiquaries to hasty generalization; and secondly, and, perhaps, more especially, to what I will term a vicious system of arranging museums, which has prevailed to some degree in all countries. The proper, and the only correct, arrangement of a museum of antiquities is, no doubt, the *ethnological* one. Relics of antiquity should be classed according to the peoples and tribes to whom they are known or believed to have belonged, and to the localities in which they are found, and then only have they any intelligible meaning. Thus, to take an example, flint articles found in the district of Bridlington have not necessarily any connexion with articles of flint which might be found, for instance, in Herefordshire, or in Wiltshire, either with respect to the people who made them, or originally possessed them, or to the period to which they belonged. If, therefore, we wish to understand these relics, and to derive advantage from them, we must look at those of each locality by themselves, and pay attention in each case to the circumstances connected with them individually. But people have been adopting a practice of placing flint implements with flint implements, bronze with bronze, and iron with iron, until, forgetting entirely the real elements which give them an individual meaning, they begin to look at them just as if they were so many fossils belonging to such and such geological strata, and thus form systems which are pretty and attractive to look at, but which, in truth, belong only to the imagination.

It will, perhaps, not be occupying the time of the Society quite fruitlessly, if we enter a little more in detail into this now rather celebrated system of periods. And first, with regard to the stone-period,—I do not mean at all to deny that the prevalence of implements, like those I have been describing, made of stone, must be considered as characteristic of a low degree of social development; and, in fact, it seems to imply the ignorance of metals, or the incapacity to work them. This, however, is by no means a necessary consequence. When communication between one place and another, even at short distances, was slow and difficult,—which was the case not only among the ancient inhabitants of this island, but comparatively even down to very recent times—people were commonly obliged to use the materials they had ready at hand, from the impossibility of obtaining a regular supply of material of a more appropriate character. It is probable that if one of the tribe of the Parisi, or several together, set off to a place no farther off than York to seek a supply of materials, he or they ran the imminent risk of never returning. Metal of any kind, therefore, might be an article of which they depended for a small and precarious supply on some itinerant dealer, who, of course, could not be expected to carry with him any large quantity. It is, therefore, quite possible that the use of metal and the use of stone for such implements may have existed co-temporaneously. We have, indeed, sufficient evidence that they did so exist. We find stone implements along with bronze implements, in what are considered as the earliest sepulchral tumuli in this island. Stone implements have sometimes been found on Roman sites. Douglas found one of the stone implements usually called a celt, in a Saxon grave, in Greenwich Park. I myself recently took from an Anglo-Saxon grave in the Isle of Wight, lying among implements of iron, pieces of chipped flint closely resembling those met with in the neighbourhood of Bridlington. I believe, indeed, that one of the chroniclers of the Norman conquest speaks of weapons of stone as used by some of the Anglo-Saxon troops at the battle of Hastings. Again, there are two circumstances to which I would particularly call your attention. Many of these implements in stone must have been made with metal tools. This is particularly the case with some stone articles of a higher finish. It appears to me that even the flint implements can only have been chipped with metal, and I suspect, moreover, that that metal was iron. Secondly,—it seems to me equally evident, that most of these implements in stone were really copies of similar implements in metal. The stone axe found by Mr. Cape, and engraved in one of the accompanying plates, is, I believe, a mere copy of a Roman axe. I cannot imagine that any one would have thought of making a barb to a fishing hook of flint, unless he had previously seen a barbed hook of metal. Nor does it seem any more natural that people who were reduced to making such articles by chipping them out of flint, should have thought of making a barbed arrow-head, when one without barbs would have served the purpose equally well, unless they took the idea from a model made of some kind of metal, and furnished by a more civilized or a richer people.

Secondly,—with regard to the so-called *bronze-period*, I confess that I see no reason why the use of bronze should naturally precede that of iron. I need hardly remark that bronze is a mixed metal, and that it was first made, in countries where there was no iron, (as in Greece and Italy,) in the attempt to harden copper that it might be made available for weapons, or for other edged or pointed instruments. But I know not why, in a country like Britain, in some parts of which iron was found almost on the surface of the ground, and at times so extremely rich in ore as to be almost malleable, this metal should not have been in use quite as early as either bronze or copper. I must remind you that Cæsar tells us that in his time, while iron was procured in the island, the brass (*æs*,) by which, no doubt, he meant bronze, used by the Britons, was imported from abroad.

There are certain peculiarities in the articles of bronze usually ascribed to the *bronze-period*, which deserve our special attention. They consist chiefly of swords, of a form which antiquaries seem agreed in describing by the epithet of leaf-shaped, and of bronze axes, chisels, and other similar weapons, to which has been given the rather incongruous name of celts, concerning which I will only remark that the sooner it is laid aside the better. The leaf-shaped swords are found, I believe, in almost all parts of the Roman empire, as well as in the barbaric countries on its border, though more numerous in the latter, and under different circumstances. They are found not unfrequently within the Roman province of Britain, but always, I think, in places where they seem to have been thrown accidentally, and not under circumstances which would lead us to identify at once the people who left them there. On the contrary, when they are found in Ireland, (where they are rather plentiful), in the parts of Scotland beyond the limits of the Roman province, in Scandinavia, and even as far eastwardly as Hungary, we are naturally led to assume that they belonged to the natives of those countries, and, in fact, they are sometimes found interred in their graves. It has, therefore, been assumed that these swords were the weapons peculiar to the primitive populations of those countries which the Romans had not conquered, and of the Celtic populations of these islands before the Romans visited them. The same remarks apply to the so-called bronze celts, except that the latter have been found in our island more undoubtedly with Roman remains. It must be remarked, as at least partly explaining the difference in the circumstances of the finding of these articles, that the Romans were not in the habit of burying *their arms with the dead*, which, on the contrary, was a general custom among the Celtic and Teutonic races.

Now it is a remarkable circumstance that, whenever we find the swords, or the "celts," along the whole line of the European limits of the empire, whether in Ireland in the far-west, in Scotland, in distant Scandinavia, in Germany, or still farther east in the Sclavonic countries, they are the same—not *similar* in character, but *identical.* It is certain that these countries were not occupied by peoples of the same race, nor is it at all probable that there was at any time (except through the Romans,) a direct intercourse between the people on the borders of Russia and those of Ireland; and it seems to me that we should be led almost irresistibly, by the fact just stated, to the conclusion, particularly since we find them within the Roman empire, that these objects did not really belong to the countries where they are found, but that they must have been manufactured for them in some central position common to them all—in fact, that they were made in the Roman empire, and sold to the barbarians, just as now, at Birmingham and in others of our great manufactories, articles are made for exportation to suit the tastes of the Indian of America or the Negro of Africa. There are known facts which corroborate this view of the matter.

At an early period, local inter-communication was extremely difficult and extremely slow, for people in general had to travel on foot, and their travelling was surrounded with danger. We know that not many years ago, before stage-coaches were generally introduced, the whole population of a village or small town remained so closely attached to the spot, that any one of them who had visited a distant village or two, was looked upon as a remarkable personage. Much more was this the case at the remote period of which we are speaking. Under such circumstances, the internal commercial relations of a country were very small. At a later period of the middle ages, the inconvenience arising from this circumstance was in a small degree obviated by the establishment of fairs, to which merchants and manufacturers repaired at certain periods of the year, and at which people bought and laid up sufficient stores for the interval. But before the establishment of these fairs, a great part of the trade and manufactures of a country was in the hands of wandering dealers or workmen, such as in more modern times are termed *pedlars*, a name probably derived from the circumstance that these dealers went on foot. Men who sold certain articles, or who practised certain arts, wandered thus over an immense extent of territory; they received to a certain degree the same kind of protection as minstrels, and passed often from one country to another. Their arrival was looked forward to with anxiety by those who needed their services, and who had saved money for purchases, or collected materials for work. Thus, even in greater matters, people prepared their malt and other ingredients for the time when the itinerant brewer came round and made their ale; and, after gunpowder came into use, each town or great lord expected the visit at a certain period of the man skilful in making it, at whose arrival they had the materials ready. So people who had articles of any kind that needed mending, if they were not mendable in a very easy manner, laid them aside, and waited till the periodical visit of men professing to make the repairs they required.

There are curious facts illustrating this practice connected with the immediate subject on which I am treating. In various places in England, especially in the eastern and south-eastern districts, and under circumstances which leave no doubt in my mind of their belonging to the Roman period, are found not unfrequently the remains of the working stock of people who evidently went about, in the manner just described, to make implements of bronze, and these articles were the bronze celts and leaf-shaped swords. Thus, in 1845, a quantity of bronze celts, with punches, gouges, and other instruments of the same material, as well as several pieces of unused metal, one of which appeared to be the residuum left in the melting pot, were found at a village near Attleborough, in Norfolk. No less than seventy of the celts, and ten spear heads of bronze, were found together in a meadow near Stibbard, in the same county. A similar collection of bronze chisels, &c., with portions of a leaf-shaped sword, was found at Sittingbourne, in Kent. At Westow, in Yorkshire, a collection of sixty such implements, together with a piece of a broken sword, with a piece of bronze which appeared to be the residuum from melting, was found in an earthen jar or vase. I have myself seen some of a collection of whole and broken celts, gouges, &c., found under similar circumstances at the foot of the Wrekin in Shropshire, not far from the Roman town of Uriconium. I might easily extend the list of such discoveries which have been made at different times in our island; and similar discoveries have been made also in various parts of Germany, in Switzerland, and in France. Leland, writing in the time of Henry VIII., and speaking of Cornwall, tells us, " There was found of late yeres spere heddes, axis for warre, and swerdes of coper, wrapped up in lynin scant perishid, nere the mount in St. Hilaries paroch in the tynne workes." Here we find the manufactures of these articles actually brought into relation with the mining districts from which the metals were derived.

Now here, I think, the whole mystery of these bronze implements is solved. It is evident, from the frequency of these discoveries, that the *makers* were rather a numerous class throughout the Roman empire. They travelled about with their melting pot, and a certain quantity of material, to which was added the broken bronze they found at the places where they stopped to work, and which had, no doubt, been carefully preserved until their arrival, perhaps, to be taken in part payment. The actual moulds in which the celts were cast are found commonly enough. These "celts," with the chisels and gouges, appear to have been the articles made in greatest quantities within the civilised parts of the empire, because they were articles for domestic purposes; but we see that the same manufacturers did make the leaf-shaped swords, and the spearheads. There were various reasons why bronze should be used for such purposes. In the first place, it is far more easily fusible than iron, or any other hard metal; and it is evident that an itinerant manufacture like this could not be carried on conveniently with a metal which was not easily fusible. I think we may trace, also, among the Romans themselves, a sort of superstitious reverence for bronze as a metal; and it was probably considered by the barbarians themselves as handsome, and more valuable than iron. After this statement of facts, no one will, I think, be surprised when I state that on the Continent these leaf-shaped swords have been found, under circumstances which leave little doubt of their being Roman. In France, one of these swords was found at Heilly, in the department of the Somme, with other articles, among which were four brass coins of Caracalla; and another was found in another locality, along with skeletons and coins, some of which were of the Emperor Maxentius, so that they could not have been deposited in the place where they were met with before the fourth century of the Christian era.

With regard to the *iron-period* it is not necessary to say much. We all know that from the first period at which we trace the knowledge of iron, the use of it has continued without interruption. But we know also, that iron is the most perishable of all the metals. We have only to wet the blade of a knife, and in that state expose it to the air, and decomposition begins immediately. Beyond a certain date, no article in iron is preserved, except under very favourable circumstances. Every one who has been present at the opening of Anglo-Saxon graves, the average date of which may be considered as the sixth century, and in which abundance of iron implements, and especially weapons, such as swords and spears, were buried, knows how often the former existence of such articles is only traced by a darker tinge in the earth. It is, therefore, no proof that, at a period before the Roman age, (when we know that metal was used,) iron was *not* in use, that we find no remains of it.

These various considerations lead me to the conclusion, that the system of periods adopted by the northern archæologists must be rejected as having no foundation in facts. The use of stone, no doubt, marked a low state of civilization, but it depended partly on localities and their peculiar conditions, and did not belong to any particular period, or to any particular people; nor was it incompatible with the use of the metals at the same time. The same considerations seem to show that there was no *bronze-period* in the sense those archæologists give to the term; but that the articles in bronze on which they build their theory, were really of Roman manufacture, or, at least, made in Roman provinces, and were obtained by commerce. In saying this, I do not mean to deny that in the sequel, and towards the latter period of Roman rule, the barbarians themselves may have learned and practised the manufacture; because this, we know, was the common course in most manufactures, and, indeed, we can trace in many of these articles, especially in the more elaborately ornamented examples, an evident falling off from the tasteful forms which the Romans had given to them. It is to this period of degenerate art, indeed, that I attribute the mass of the more peculiar articles in bronze found in Scandinavia. Lastly, I feel convinced that the notion of there having been a period in western or northern Europe, during which bronze was in common use for manufactures, and iron was *not* known, is a mere gratuitous assumption. The inconvenience of such extensive generalisations will be apparent at once to the Ethnologist, who feels the necessity of studying peoples in detail, and taking them in their tribes and small divisions, instead of beginning with extensive and fanciful theories.

ON SOME WORKS OF MAN ASSOCIATED WITH THE REMAINS OF EXTINCT MAMMALS, IN THE AIRE VALLEY DEPOSIT.

BY THOMAS PRIDGIN TEALE, ESQ., F.L.S., OF LEEDS.

In a paper read before the Philosophical and Literary Society of Leeds, in 1853, I described a geological deposit, occupying the lower part of the valley of the Aire and of the other tributaries of the Humber, of more recent date than the Northern Drift, and containing besides the remains of other animals bones of the Hippopotamus and Mammoth, in such circumstances as to leave no doubt of their being co-temporaneous with the deposit itself.

The existence of the large Northern Pachyderms was thus brought down to the post-glacial age. Can we proceed further? Can we prove these animals to have been co-existent with Man?

In pursuing this inquiry, we must bear in mind the vast range of time during which the deposit might have been formed. It is bounded in one direction by the geological glacial epoch, in the other by the historic Roman period of Britain. There is, then, a wide range of time during which the great northern Pachyderms may have existed; but the precise time when they became extinct, and when Man first migrated to Britain, we are unable to determine. It is, however, a legitimate subject for investigation whether at any period of post-glacial age these Pachyderms and Man were co-existent. This inquiry would be answered in the affirmative if we could prove that the Valley deposit of the Aire, which contains Pachydermatous remains co-eval with itself, contains also co-eval remains or works of Man.

Before proceeding further, I must call to mind what is too often lost sight of—the vast extent of time before the Roman era during which these lands were inhabited by Man. Fourteen hundred years and more before the Christian era Phœnician fleets traversed the seas to North Africa, Arabia, and China; they also traded to the Baltic for Amber, to Spain for Silver, and to Britain for Tin; during many centuries they continued their commercial intercourse with the British Isles, and for some centuries afterwards they were succeeded by the Carthaginian traders. Of the geological and social events in Britain during these fourteen centuries we have no written records, but man has left abundant traces of his works which attest his existence, and his progressive advance in the arts of civilized life. These unwritten records, well styled by the learned secretary of the Society of Scottish Antiquaries,* Pre-historic Annals, are now receiving, as they deserve, the serious attention of the antiquary, who is combining with the geologist to decypher these dark pages of our race. The aid that it is in my power to give to these inquiries is indeed but small; nevertheless, such facts, bearing upon the subject, as I have met with, I feel bound to record.

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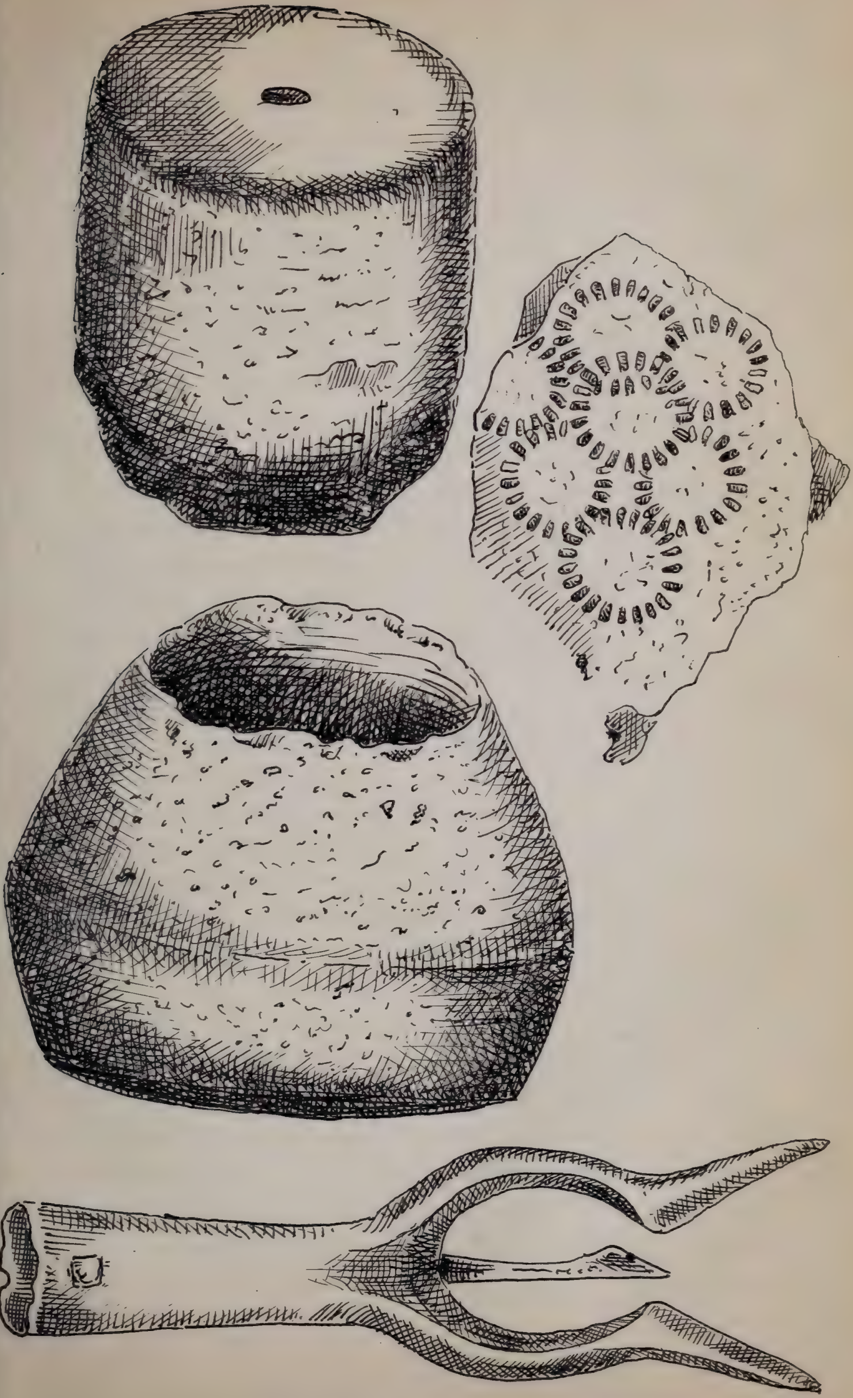
* Pre-historic Annals of Scotland, by Daniel Wilson.

Whilst engaged in examining the excavation at Wortley, where the bones of the Hippopotamus were found, I inquired if any works of man were ever found along with the trunks of trees and the bones. The workmen whom I addressed replied that a brickmaker who had long been engaged in the business, had found a hewn stone in the clay of the adjoining field. On repairing to the house of this person, who lived near, he shewed me the stone, and also two pieces of pottery which he found at the same place. He gave me a straightforward account of the place in which they were found, five feet deep in a six foot bed of clay. They were not in juxta-position, but at some little distance in the same excavation. On being questioned whether they might not have been inserted into the clay from above, he replied that this could not have been the case, as there was not the least appearance of the bed of clay having been disturbed from above, and he stated that they were silted over with clay in the same manner as the pieces of trees with which they were accompanied. It should here be borne in mind that these objects were regarded by the men as unmeaning curiosities, that they were not palmed upon me, but were sought out by me. I cannot, therefore, in the least doubt the good faith of the man. He may have been in error as to the peculiar circumstances in which they were found; but in this case the other workmen were also in error, as they separately gave the same account of these relics as himself. The hewn stone is a rounded mass of millstone grit, of an egg shape, truncated at one end; the flat surface has a round central hole, and is worn smooth by



circular attrition. In the central hole was a piece of iron much corroded.

It can scarcely be doubted that this has been an ancient quern or hand-mill. The earthen vessel is of imperfectly baked clay, shewing in its interior some marks of having been rounded into form at its base by a hand instrument, but on the exterior it is perfectly void of ornament, giving no indication of having been subjected to the potter's wheel, being also unsymmetrical in form. The fragment of glazed pottery presents on its outside several star-like marks, which have been impressed upon the soft clay by a hard material. The exterior is also glazed over with a pale green vitreous substance. The question here arises, have these works of Man been modern insertions into this ancient bed of clay, or were they co-eval with the deposit itself? Not being an antiquary I am unable to decide; but I feel called upon to say that these relics have been seen by several antiquaries; amongst whom I may mention Mr. James Wardell, of Leeds, by whose antiquarian zeal has been brought together one of the finest private collections of English antiquities. The general opinion of these parties is, that these relics are of Roman, or even of Anglo-Saxon date. Should this prove true, these works of man must have been in some way or other introduced to the depth of five feet in the bed of clay without any observable trace of disturbance of the bed having been left. Now although I think it probable that our antiquarian friends may be right, yet they have failed to give me any reasons which satisfy me that, of necessity, these works of man are not of earlier than Roman date in this country. The quern is said by some parties to be Roman, because the instrument known by this name was in extensive use in the Roman armies. The iron found along with it is also said to stamp it as Roman, since, as it is alleged, implements of iron in Britain were chiefly of

Roman introduction. But the stone quern is an utensil of the remotest human antiquity. Stone querns have been found in Ireland associated with bones of the extinct fossil Elk, at great depths in the Irish bogs, under circumstances shewing a very high antiquity. Mr. Daniel Wilson states that stone querns are found in Orkney, and the north of Scotland, amongst the earliest traces of the human race.* I must also demur to the opinion that the iron appendage of the quern determines its Roman or subsequent date. It is true that for many centuries before the Roman advent, bronze was the metal chiefly in use amongst the ancient Britons, and that iron came into much more general use after the Roman invasion, yet iron was long employed in Britain before this age. Julius Cæsar speaks of the Britons, on his arrival, as using ring money of iron. They also wore at that time personal ornaments and trinkets of iron.† The ancient bronze leaf-shaped sword had been long superseded by the iron sword in Western Europe, when the Gauls encountered the veteran legions Rome. The same is no less true of the sword of the contemporary Britons, who excited the ire of Cæsar by the aid they afforded the Gauls in their war with the Romans.

The earthen vessel has also been pronounced by some Roman, by others Anglo-Saxon, but, I must confess that its rude workmanship and unpretending form, would lead me to assign to it a much earlier date. Although it has been subjected to the action of the kiln, it appears in the imperfectly baked state of pottery which prevailed when the kiln was being introduced; and the markings in the interior, at most only doubtfully shew the action of the potter's wheel; but even if the action of the kiln and the potter's wheel were indubitably evident, yet these circumstances do not necessarily carry it down to the Roman or Saxon ages. I find that Mr. Daniel Wilson states, that the early British pottery, though at best sufficiently rude, exhibits a considerable variety, both in form and workmanship, from the coarsest specimens of unshapely sun-dried clay, to the graceful and elaborately decorated vases evidently made by workmen who had acquired a knowledge of the potter's wheel.* It is difficult to determine the time when glazed pottery was first in use amongst the Britons. In 1832, Lieut. Col. Miller presented to the Society of Scottish antiquaries, one of several fragments of glazed pottery, which were found in Fifeshire, along with a barbed arrow head of flint, an iron dagger, a bronze fibula, and a quantity of bones and ashes.† In 1842, two stone cists were discovered in Berwickshire, each containing a human skeleton, an iron sword and dagger, and urns of rough grey earthenware, ornamented externally with parallel grooves running round them, and internally covered with a green glaze. Although these examples of glazed pottery do not lead us to form a certain opinion of the date of their fabrication, yet they evidently belong to an age before the time when the works of the ancient Britons in the north had become influenced by Roman art, and before the use of iron had entirely superseded the primeval arrow head of flint. In these circumstances, then, I think we may fairly suspend judgment for the present, as to the date of these works of man which I have described.

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* Wilson's Pre-historic Annals of Scotland, pp. 423–425. † Ibid, p. 341.

An eye-witness, Mr Thomas Tilney, who was present during the excavation for the Wesleyan Chapel, in Meadow Lane, Leeds, about 40 years ago, informs me that at the depth of 18 feet in the gravel was found a human skeleton, near which were some buckles, (fibul) and a spear head. He assured me that the skeleton and its accompaniments had every appearance of having been drifted to the place along with the sand and gravel, and he is quite con-

* Wilson's Pre-historic Annals of Scotland, p. 280 † Ibid, p. 453.

fident that the superincumbent gravel of 18 feet in thickness had not been disturbed from above.

During the late excavation for the sewerage in Hunslet Lane, along with the bones of the deer, ox, and horse, was found an iron horse-shoe. In the neighbouring valley of the Calder, at Altofts, was found in 1842, a dagger head of bronze. At the place where it was found there is a thickness of 24 feet of the valley deposit resting upon the coal formation. The section of the deposit at this part shewed sand, gravel, sand and silt, with blackwood-gravel. The dagger-head was found in the lower portion of the deposit, very near to the coal-measures. It was laid flat, and above it were the masses of drifted wood. A few miles higher up the Calder, at Stanley, was discovered a portion of an ancient canoe imbedded in the deposit at a depth of 18½ feet, and about six feet below the present bed of the river, along with a number of oak trees, quite solid and black. The canoe had been hewn out of a solid block of oak, as was the custom with the ancient Britons. An account of these remains from the valley of the Calder has been published by Mr. Wilson, of Crimbles House. *Reliquæ Antiquæ Eboracenses*, page 40.

Whilst writing this paper, I have met with the following remarkable passage quoted from Leigh's History of Cheshire, by Mr. De la Pryme, in the Philosophical Transactions for 1701. "In draining Martin Meer, a few years ago, were found multitudes of roots and bodies of great firs in their natural position, with great quantities of their cones, and eight canoes, such as the old Britons sailed in; and in another meer was found a brass or bronze kettle, beads of amber, a small millstone, the whole head of an hippopotamus, and human bodies entire and uncorrupted."

Far be it from me to suppose that these few instances of the works of man found in our valley deposit are sufficient to determine the co-existence in these lands of the large extinct

Pachyderms and Man, opposed, as this opinion is, to the general voice of geologists. Much more numerous facts, critically observed, and divested of all possibility of error, must be accumulated before our own, or a more general, assent should be given. Nevertheless, I have thought it right not to withhold such facts as have come within my reach. This is done in the hope of directing attention to the subject, and of shewing the importance of the most rigid notice of similar facts in future. Each should hereafter be noted on the spot, and every circumstance that can give value to the observation truthfully recorded. Before concluding, I would urge those who may be engaged in such inquiries, not to be discouraged by the united voice of geologists. A gentleman, more conversant with the geology of Yorkshire than any other person, has published within the last four years a statement that the Yorkshire deposits of post-glacial date, are characterized by the absence of the large Pachyderms.* This statement we have proved to be unfounded, by the discovery of the Hippopotamus and Mammoth in this district, in a deposit which the learned and excellent Professor himself, at the late meeting of the British Association at Hull, admitted to be of post-glacial date. Such being the case, I may not be considered presumptuous in saying that it will not cause me much surprise to find both the geologist and the antiquary some day admitting that the great northern Pachyderms have been co-eval with man.

In connection with this paper, Mr. Denny read the following brief notice of an instrument supposed to have been a Leister, lately presented to the Museum of the Leeds Philosophical and Literary Society, by Thomas Newsome, Esq. :—

In 1851, when excavating for the terminus of the sewerage of this town, on the South side of the Suspension Bridge, below Knostrop, a Leister of iron, or at all events an instrument similar in appearance, and presumed to have been used for the same purpose, was found in a bed of gravel at the depth of ten feet, together with portions of wood, and one or two other articles of human construction, one is described as somewhat like a saw, which has since been unfortunately lost. As the excavators who were employed on the works have left the neighbourhood, no information can now be obtained as to their precise nature, or the parties into whose possession they may have passed. The Leister, which is of wrought iron, consists of three prongs, has been fixed upon a pole or handle, by a rivet, and exhibits in its construction ample proofs of the advanced state to which the working of metals had arrived at the period of its deposition. It is somewhat singular that this instrument is very similar to a Leister figured in "Lloyd's Scandinavian Adventures," as used at the present day by that people, and the author says, "is supposed to be the most ancient fishing device adopted by the Scandinavians." Can this similarity of instrument throw any light upon the early colonization of this part of Yorkshire?

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* Rivers, Mountains, and Sea Coasts of Yorkshire, by John Phillips, 1853, p. 187.

Mr. C. Beckett has shewn in a paper read before the British Association, at Hull, in 1853, that different races of men colonized the north and south banks of the Humber, whose descent can be traced to this day by their peculiar dialects. Professor Phillips also states that the physiognomy as well as dialect, distinctly marks three different groups of men as the progenitors of the inhabitants of the North and West Ridings of Yorkshire. The successive incursions of the Romans, Saxons, Danes, and Normans, is also attested by the various relics which mark the sites of their territorial possessions, as well as indicate the warlike or domestic habits of the people.

Now as the country on the east side of Leeds, extending towards Selby and the banks of the Humber, is low and marshy, and was, probably, at a remote period, connected with an extensive inland lake, is it too much to suppose that the Leister to which I have alluded, was one lost by some Scandinavian fisherman who was following his occupation in this district?

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FORTY-FIFTH (THE ANNUAL) MEETING, HELD IN THE PHILOSOPHICAL HALL, LEEDS, ON THURSDAY, JAN. 22ND, 1857, JOHN HOPE SHAW, ESQ., IN THE CHAIR.

Mr. Shaw said that at the request of the Council of their Society he again occupied the honourable position of President on the occasion of their meeting in Leeds—an honour of which he was deeply sensible, but to which he had no pretensions whatever on his own account, save the official character which he held within those walls. When he welcomed the Society to Leeds some years ago, it was in the character which he at that time filled of Chief Magistrate of the borough; and he now welcomed them as the President of the Philosophical and Literary Society of Leeds. Following the programme of the proceedings of the Society for some years past, he saw that the first engagement that morning would be the transaction of what they might properly call the business of the Society itself: that was, to appoint the gentlemen who were to fill the various offices connected with the Society for the year upon which they were about to enter; and next, they would receive a statement of the financial position of the Society from the Honorary Secretary. After that business had been transacted, they would come to another principal object of the proceedings of the day, namely, the reading of papers. Those papers would be chiefly upon subjects which had not, up to that time, been usually brought under the consideration of the Society. The object of the Society, as stated in the rules, was to obtain information bearing upon the mineral resources of the district and the manufactures connected with them, and on the condition of the population engaged in the operations connected with these minerals and manufactures. And, certainly, these had very properly formed,—and he trusted would continue to form,—prominent objects of consideration whenever the Society met; but, within the meaning of the word "polytechnic," in its more extended sense, were included works of art. The present meeting would be partly occupied in listening to a paper relative to Roman coins, discovered in this county, and which, through the liberality of a Yorkshire nobleman, Lord Londesborough, had been presented to the Yorkshire Philosophical Society, and the Leeds Philosophical and Literary Society. Two papers would also be read upon those very interesting relics of antiquity, the crosses discovered on taking down the Parish Church of Leeds, nearly twenty years ago—in 1838—the origin of which would, no doubt, be the subject of discussion. One of the learned authors of these papers (the Rev. Mr. Haigh) was present; the other (Mr. Chantrell) whose researches were so well known as to entitle his opinions to the greatest respect was unable to attend. He did not know precisely what views these gentlemen entertained in regard to these crosses, but he was sure that all would listen to them with much interest. In inquiries of this kind, though the antiquity of the subjects might not be so obvious as those which, according to the usages of the Society, claimed the principal portion of its attention, yet the difference was not so great as it appeared at first sight. They were valuable records which might tend materially to elucidate history at a period when written history was very obscure; and they were certainly of great and peculiar interest to antiquarians connected with the country, and especially to Yorkshiremen. The other paper, to be read by Mr. Denny, was strictly a geological one; it related to the head of a dog discovered at Norwich. The inquiry, he supposed, would be as to the origin, the authenticity, and probable date of this deposit, and as to the inferences which the scientific geologist would be justified in drawing from it.

On the motion of the Chairman, Wm. Dowse, Esq., of Doncaster; John Brown, Esq., of Barnsley; George Morley, Esq., of Leeds; and E. W. Shaw, Esq., of Leeds, were unanimously elected as Members of the Society.

G. S. Beecroft, Esq., proposed the following noblemen and gentlemen as the Officers and Council for the ensuing year:—

President.

EARL FITZWILLIAM, F.R.S.

Vice-Presidents.

The Duke of Norfolk.
The Duke of Leeds.
The Earl of Effingham.
The Earl of Dartmouth.
Lord Wharncliffe.
Lord Londesborough, K.C.H., F.S.A.
Viscount Milton, M.P.
Viscount Galway.
Viscount Goderich, M.P.
Rt. Hon. Sir Charles Wood, Bart.
Edward Akroyd, Esq., M.P.
T. W. Beaumont, Esq.
E. B. Denison, Esq., M.P.
William Beckett, Esq.
R. M. Milnes, Esq., M.P.
J. S. Stanhope, Esq.
Godfrey Wentworth, Esq.
J. G. Marshall, Esq., F.G.S.
Michael Ellison, Esq.
Rev. William Thorp.
John Waterhouse, Esq., F.R.S.
Thomas Wilson, Esq.

Council.

Henry Briggs, Esq.
Dr. Wm. Alexander.
T. W. Embleton, Esq.
H. C. Sorby, Esq., F.R.S., F.G.S.
Michael Stocks, Esq.
E. B. Wheatley, Esq.
Henry Holt, Esq.
Benjamin Biram, Esq.
Dr. Wm. Paley.
R. Carter, Esq.
John Jebson, Esq.
T. P. Teale, Esq., F.L.S.

Honorary Secretary.

William Sykes Ward, Esq., F.C.S.

Honorary Curators.

T. W. Embleton, Esq.
J. G. Marshall, Esq., F.G.S.

Auditors.

Benjamin Biram, Esq. | G. W. Chambers, Esq.

Local Treasurers and Secretaries.

Dr. Wm. Alexander, Halifax.
Henry Briggs, Esq., Wakefield.
H. C. Sorby, Esq., Sheffield.
R. D. Baxter, Esq., Doncaster.

Mr. Ward, the Honorary Secretary, having read the financial position of the Society, which was as follows:—

STATEMENT OF THE RECEIPTS AND EXPENDITURE

Of the Geological and Polytechnic Society of the West Riding of Yorkshire,

From December 13th, 1855, to January 22nd, 1857.

DR.	£.	s.	d.
By Balance in Mr. Battman's hands	8	8	6
,, Balance in Treasurer's hands....	6	13	8
,, Subscriptions—			
From 5 Members for 1853	3	5	0
,, 8 ,, 1854	5	4	0
,, 56 ,, 1855	36	8	0
,, 74 ,, 1856	48	2	0
,, Donation from the Mayor of Halifax	1	0	0
	£109	1	2

CR.	£.	s.	d.
To Collecting Subscriptions	2	17	10
,, Postages	2	0	6
,, Rent of Museum................	20	0	0
,, Messrs. Baines, on Account	20	0	0
,, Advertising Meetings	1	18	6
,, Expenses of Meetings	2	0	0
,, Subscription to Palæontographical Society	1	1	0
,, Lithographing & Printing Plates	2	1	0
,, Assistant Secretary on Account	39	9	9
,, Stationery	0	4	6
,, Sundries, Carriage, &c...........	1	3	1
,, Deficiency in Mr. Battman's Accounts	8	8	6
,, Balance in Treasurer's hands....	7	16	6
	£109	1	2

LIABILITIES.	£.	s.	d.
Messrs. Baines	31	8	8
Philosophical Hall, for rent	10	0	0
Palæontographical Society...........	1	1	0
Salary of Assistant Secretary	22	0	3
	£64	9	11

ASSETS.	£.	s.	d.
Cash in Treasurer's hands	7	16	6
Arrears of Subscriptions to collect..	42	9	0
	£50	5	6

The Secretary announced that the Rev. John Kenrick, who was unavoidably prevented from being present, had entrusted his paper to him, which he would, therefore, now read:—

REMARKS ON SOME COINS DISCOVERED NEAR WARTER, AND PRESENTED BY LORD LONDESBOROUGH TO THE MUSEUMS OF THE YORKSHIRE PHILOSOPHICAL SOCIETY AND THE LEEDS LITERARY AND PHILOSOPHICAL SOCIETY.

BY THE REV. JOHN KENRICK, M.A.

In the course of last year, a discovery of a large number of Roman coins was made near Methall, between Warter and Nunburnholme, in the East Riding of this county. On Mr. Newton's map of the Roman roads in Yorkshire, a road is laid down near this spot, passing from Market Weighton, over the Wolds, to Malton, and many antiquities have been found at Warter, so that it has been suggested, among other places, as the site of the Delgovitia of Antoninus' Itinerary. The number of the coins was very considerable; between 1,200 and 1,300 of them have been presented by Lord Londesborough to the York Museum, and many have passed into other hands. They are all of the size called by numismatists, *third brass;* they begin with the reign of Valerian, and include the reign of his son Gallienus, and his consort, Salonina; the Tyrants, Postumus, the Tetrici and Marius; the Emperor Claudius Gothicus and his brother Quintillus; and Aurelian, Tacitus, and Probus. The time of the deposit, therefore, is probably that of Probus, who reigned from A.D. 276 to 282. Like many hoards it was contained in an earthen vessel, a mode of preservation which, from the language of the Apostle Paul—"We have this treasure in earthen vessels" (2 Cor. iv. 7,) appears not only to have been used for protection against the damp of the earth, as in Jeremiah xxxii. 14, but as an ordinary custom. When Lord Londesborough presented that part of the hoard which came into his hands to the museum of the Yorkshire Philosophical Society, he requested that any duplicates might be sent to the Literary and Philosophical Society of Leeds. This has accordingly been done by the Rev. Charles Wellbeloved, the curator of antiquities, and 262 coins have been sent. It appears due to the noble donor that they should not be consigned to the society's cabinet without some more detailed notice. It is true that none of them are rare; they are of minute size, of coarse workmanship and debased metal; but these circumstances, which diminish their value in the eyes of the collector, do not prevent their being of historical interest. They are an index of the times in which they were produced—times of general calamity, of public and private poverty. All such remains of antiquity give definiteness and certainty to our historical conceptions. When we merely read history, its characters pass before us very much as figures in a phantasmagoria; but when we see the armour in which the men of fifteen centuries ago fought, the household vessels in which they prepared or took their food, and the coins which passed through their hands, we feel that they were realities and of kin to ourselves.

The series of these coins begins at a time of deep degradation and misfortune to the Roman empire. Valerian had been made captive by Sapor, King of Persia, who made use of him as a footstool to mount his horse; and, after death, caused his skin to be stuffed and hung up as a trophy in one of the temples. During the reign of his son Gallienus, the dismemberment of the empire seemed imminent; its frontiers suffered from the invasion of the barbarians, several provinces made themselves independent, and the physical calamities of earthquakes, pestilences, and inundations were added to political misfortune. But a better time succeeded. Claudius Gothicus repelled the Alemanni from Italy, and the Goths from Greece; Aurelian re-established the Roman power in the east, subdued the factions of Rome, and surrounded the city with a wall of such strength and circuit that she seemed secure from the attacks of the barbarians. By him and his successors, Tacitus and Probus, the unity of the empire was restored and upheld.

The most remarkable result of the state into which the imperial power fell, during the reign of Gallienus, was the springing up in all parts of those whom history calls the Thirty Tyrants, though without any great propriety, since their number did not literally amount to thirty, nor did they deserve the appellation of tyrants, if that name is understood to convey the idea of usurped power, or a cruel and selfish use of it. The talents of Gallienus were by no means contemptible, but they fitted him rather for excelling in dilettante pursuits, than in the administration of affairs. He frequently roused himself from the indolent voluptuousness in which his life was ordinarily spent; on several occasions he vigorously repelled the barbarians,* and he died the death of a soldier in the camp before Milan.† But he was not the man whom the age required, and we cannot wonder that leading men in the provinces endeavoured to set up independent governments. Gibbon contented himself with saying on their behalf, that they were much oftener driven into rebellion by their fears than urged to it by their ambition. Sir Francis Palgrave, in his English Commonwealth (ch. xi.), advances a higher claim for them. He regards them as the forerunners of the founders of the independent kingdoms of the west, and denies that they were in any sense usurpers. The central authority was too weak to afford protection to the provinces, which were, therefore, fully justified in providing for their own security; and the legions of Gaul had as good a right to choose an emperor as the Prætorians of the capital. Probably it was with the assent of the people that many of them reigned, and there can be no question that there were among them men of superior talent and virtue. But it is equally clear that their attempts were premature. Not one of them succeeded in permanently establishing an independent power—not one of them, according to the remark of Gibbon, enjoyed a life of peace, or died a natural death. Tetricus, however, was an exception. Of the nineteen who really attempted to set up independent sovereignties, or aspired to the empire, some passed so rapidly away that they have left no trace of themselves in the Roman coinage. But the coins of the Gallic aspirants to sovereignty, Victorinus, Postumus, Tetricus and his son, are very abundant, especially in Gaul and Britain. In this age, Gaul, Spain,

* Trebell, c. 4. † Zosim, i. 41.

and Britain were generally united in one hand, whether in case of usurpation, or of a legitimate division of power among the Cæsars. Indeed, it was hardly possible that if Gaul, which possessed all the ports opposite to Britain, was hostile, Britain could be retained by a power seated at Rome. Whether any of them ever visited this island is uncertain, but inscriptions to Postumus, Victorinus, and Tetricus have been found in Britain,* and their presence here is not improbable. The abundance of their coins is a proof of the active intercourse which was carried on between Britain and Gaul.

Although, as we have already remarked, the coins of the Nunburnholme find are not very valuable in the estimation of the numismatist, they are not without interest for the historian, as throwing light upon the events and ideas of the age. Several circumstances indicate the increase of solar worship among the Romans. This was the result of increasing intercourse with Asia, and especially with Syria, the chief seat of this species of superstition. On several of the coins recently found, the sun appears in a human form, holding a scourge or the globe in his hand, with the legend Oriens Aug. [Augusti] or Augg. [Augustorum] oriens being used for the rising sun, without the addition of Sol, as in the line of Virgil, Georg. i., 250 :—

> Nosque ubi primus equis Oriens adflavit anhelis,
> Illic sera rubens accendit lumina Vesper.

The *Augustus* was the associate and apparent heir of the reigning emperor, and was appropriately represented by the *rising* sun. We first find this figure and inscription on the coins of Hadrian. He spent much time in the east, and during the century to which our coins belong, many circumstances favoured the increase of solar worship. The Emperor Elagabalus was a high priest of the solar god, whose name he bore. Alexander Severus was a Syrian, and as a portent of his future destiny to empire, the sun had appeared with a crown of rays over his father's house on the day of his birth. The mother of Aurelian was a priestess of the sun ; he himself was so devoted to this worship, that he built a splendid temple to the sun at Rome. The emperors of this period all wear, instead of the wreath of bay, the radiated crown, the emblem at once of divinity and of the solar rays. Gallienus frequently appeared in public with it on his head. To the same inclination towards the worship of the heavenly luminaries I should attribute the circumstance that the bust of Salonina, the wife of Gallienus, and some later empresses, is placed on their coins over a crescent moon. A disposition to neglect the gods of their own mythology for those of Egypt and the east, is apparent in all this period of Roman history, and is one among many indications that Paganism had become a "creed outworn," and was on the eve of giving place to a purer religion.

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* Archæol. Vol. 4, p. 7. Winchester Congress, p. 163.

The misfortunes of the reign of Gallienus appear to have awakened all the superstitious feelings of the people, and, according to ancient custom, the Sybilline oracles were consulted. They enjoined sacrifices in propitiation of the gods, and especially to Jupiter Salutaris. To this excited state of the public mind, Eckhel refers the circumstance that such an extraordinary number of coins of this reign bear figures and legends of the gods. The Nunburnholme collection contains coins inscribed to Jupiter Conservator, Jupiter Propugnator, Jupiter Ultor, Sol Conservator, Neptunus Conservator, Apollo Conservator, Diana Conservatrix, Liber Pater Conservator, and Mars Pacifer. We may, with some probability, refer to the same state of alarm respecting the public welfare, the singular inscription of a coin of the Empress Salonina, "Deæ Segetiæ." She is a goddess who would be sought in vain in Tooke or Keighley, yet she had been worshipped by the common people of Rome since the foundation of the monarchy.* In conjunction with Seia, the goddess of the sown corn, and Tutilina, who protected the barn and the rick, she formed a triad of agricultural deities, and was invoked probably, on this particular occasion, to avert or remove the calamity of famine.

The coins of Postumus, who made himself independent in Gaul, are remarkable for the variety of characters in which Hercules appears upon them. We find the Nemean, the Erymanthian, the Libyan, the Thracian, and other classical names, and the same great numismatist, Eckhel, supposes that as Hercules cleared the world of robbers, monsters, and wild beasts, Postumus wished to claim the merit of having delivered Gaul from the Franks and Germans, and from the tyranny of Gallienus. One of his coins, in the Nunburnholme find, is inscribed Herculi Deusoniensi. Deuso was probably Duisburg, near Cologne, and though no victory of Gallienus over the Germans in this place is recorded, the coin seems to allude to such an event.

The coins of Claudius Gothicus exhibit numerous examples of the consecratio, or apotheosis, of the deceased emperor, which is sometimes symbolised by an altar, sometimes by an eagle, sometimes by a *thensa*—the sacred vehicle in which the images of the gods were carried in procession, and sometimes by a winged victory bearing the soul of the deceased emperor to heaven. The honour of consecration was well deserved by Claudius Gothicus, but it was equally bestowed on Claudius Cæsar, on Commodus, Caracalla, and Gallienus.

One circumstance which remarkably distinguishes the ancient coinage, and particularly the Roman, from the modern is the great variety of its types; of the 70 coins of Gallienus contained in the Nunburnholme find, one half differ in their types, and the whole number of types in his coinage amounts to 276. Some writers have even supposed that no more than one coin was ever struck from one die. This was not the case, and yet perfect correspondence is very rare. If their dies were of brass, as there is some reason to suppose, this would account for frequent change. The Romans, though deficient in poetical genius, were very fertile in allegory, and hence the variety of symbolical types which we find on their coins.

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* Augustin de Civ. Dei. iv, 8. Plin. N. H. xviii. 2.

It is not probable that any of the coins of this period were struck in Britain. Those of Valerian, Gallienus, and Claudius Gothicus would naturally be struck at Rome; those of the Gallic Tyrants at one of the three mints of Gaul—Arles, Lyons, and Treves. Carausius may have coined money in Britain, and Constantine is thought to have established a mint in London, but even this is not certain.

These few remarks may serve to justify what I have before said, that the coins of the Nunburnholme find, though neither "rich nor rare," are yet capable of affording instruction, and reflecting some light on the history of the times.

ON THE FRAGMENTS OF CROSSES DISCOVERED AT LEEDS IN 1838. BY THE REV. DANIEL HENRY HAIGH, OF ERDINGTON.

There can be no doubt as to the age and use of the fragments of crosses which were discovered, in the year 1838, in the walls of the belfry and clerestory of the old Parish Church of Leeds. They were sepulchral memorials, erected, perhaps, at different periods from the seventh to the tenth century. Of such memorials we find occasional notices in our early chronicles. Simeon of Durham, for instance, who wrote early in the twelfth century, tells us that Ethelwold, Bishop of Lindisfarne, caused a cross to be erected in the cemetery of Lindisfarne, and his own name to be engraved upon it;

and that it was designed as a memorial of his predecessor, St. Cuthbert, is evident, for afterwards, when the monks of Lindisfarne were compelled, by the invasion of the Danes, to leave their monastery, and carried the body of St. Cuthbert with them, this cross accompanied them in all their wanderings; and when they finally settled at Durham, it was set up in the cemetery there, where it continued until the sixteenth century, (the time of Leland,) who tells us that it was venerated by the Northumbrians as associated with the memory, not only of the saint who caused it to be made, but of St. Cuthbert also.

Again, after mentioning the death of St. Acca, Bishop of Hexham, in the year 740, and his interment in the cemetery there, Simeon says, "two crosses of stone, "decorated with wonderful carving, were placed, one at his "head the other at his feet; on one of which, to wit, that "which is at his head, there is an inscription to the effect that "he is buried there." These crosses, I believe, are still in existence, though both imperfect, and one in fragments.

Again, William of Malmsbury describes two magnificent monuments which existed in his day in the cemetery of Glastonbury Abbey, which he calls pyramids,* because, like all others of this class, they taper from the base to the summit, and had lost the crosses which once terminated them. He says, "Willingly would I explain, could I but ascertain "the truth, what is a mystery to almost every one, what those "pyramids mean, which, placed a few feet from the church, "stand on the border of the monks' cemetery. The loftier of "the two, and the nearer to the church, has five panels, and "is twenty-eight feet high; this, threatening ruin from its "great age, has yet some features of antiquity which can be "plainly read, though not fully understood. In the highest "panel is an image in the habit of a bishop; in the second a

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* In another account they are styled "obelisks."

"figure vested like a king, and the letters HER SEXI and "BLISPERH; in the third also are names, PENCREST, "BANTOMP, PINEPEGN; in the fourth, BATE, "PVLFRED, and EANFLED; in the fifth, which is also "the lowest, there is an image and this inscription, LOGOR, "PEAS LICAS, and BREGDEN, SPELPES, HIPIN "GENDES BEARN. The other pyramid is twenty-six "feet high, and has four panels, in which are read these "words:—CENTWINE, HEDDE EPISCOPVS and "BREGORED and BEORWARD. What these mean "I do not rashly decide, but I suspect that their bones are "contained within, in stone coffins, whose names are read "without."

In the Antiquities of the Church of Glastonbury, by the same author, we have another description of these monuments, with some variations in the reading of the inscriptions, as follows. On the first:—

HER.SEXI. BLISYER
WEMEREST BANTOMF PINEPEGN
HATS PVLFRED EANFLED
LOGPORPESLICAS
BREGDEN SPELPES
HYINGENDES BERN

On the second:—

HEDDE EPISCOPVS
BREGORED BEORWARD

It is to be observed, that this author describes but one side of each monument, that on which there were images; from which it is probable that, like the cross at Bewcastle, they had images on one side only, and on the others, knots and scrolls, which he did not think it necessary to mention.* From the readings he gives it is impossible to make out the whole of the inscriptions satisfactorily, though it is clear that the inscription on the larger monument was in Anglo-Saxon, and contained Anglo-Saxon names, Wulfred and Eanfled and others; and that on the other were four names, of which two are of historical interest, and enable us to determine the period at which these obelisks were erected, that is, the beginning of the eighth century; for Centwine was king of the West Saxons from A.D. 676 to 685, when he became a monk,* and lived for some years afterwards; and Hedde was Bishop of Dorchester from A.D. 676 to 705. The alteration of one letter in the name *Beorward* would give us the name of the contemporary abbot of Glastonbury, *Beornwald; Bregored* appears to have been one of his predecessors in the abbacy; but I have no means of identifying *Wulfred*, or *Eanfled.* Here, then, were two of this class of monuments, recognized as sepulchral by William of Malmsbury, and probably erected early in the eighth century to the memory of king Centwine and Bishop Hedde. They are now utterly destroyed, for a friend, who, at my request, searched for them lately amongst the ruins of Glastonbury, was unable to find even a fragment of them.

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* This is the case, also, with one of the crosses at Hexham, already alluded to. It has scrolls on three sides, and on the fourth the Crucifixion, with traces of an inscription beneath.

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* This fact, unnoticed by the chroniclers, who supposed him to have died A.D. 685, appears from a poem of St. Aldhelm:—"De basilica edificata a Bugge filia regis Angliæ."

"Hoc templum Bugge pulcro molimine structum
Nobilis erexit Centwini filia regis,
Qui prius imperium Saxonum rite regebat,
Donec præsentis contemnens culmina regni,
Divitias mundi rerumque reliquit habenas,
Plurima basilicis impendens rura novellis,
Qua nunc Christicolæ servant monastica jura.
Exin sacratam perrexit quærere vitam,
Dum proprium linquit Christi pro nomine regnum;
Qui tamen ante tribus gessit certamina pugnis,
Et ternis pariter confecit bella triumphis.
Sic rexit regnum plures feliciter annos,
Donec conversus cellam migravit in almam,
Inde petit superas meritis splendentibus arces."

Further on, St. Aldhelm intimates that he died in the same year as Cædwalla, A.D. 688; and that he was living in that year appears from a charter, (Codex Diplomaticus XXVIII,) of Baldred to Aldhelm, given by his advice and with his sanction, and attested by his successor Cædwalla. The genuineness of this charter is proved by a letter of St. Aldhelm to Winberht, Abbot of Nutshell, in which he speaks of the grant made by Baldred, and requests him to confirm it. Accordingly the name of Winberht appears as one of the witnesses to the charter.

As a witness to the use of monuments of this kind, at a period, much later indeed, but one at which matters of this kind were better understood than they have been until lately in our days, we may cite the antiquarian traveller, Leland, who in the sixteenth century informs us that he saw, standing in the churchyard at Ripon, three crosses of most ancient work, and that he believed them to be memorials of some great and notable persons who were buried there. Nothing now remains of these, save the head of one, which is to be seen placed in a recess above the door of the Minster crypt, and its interlaced ornaments are sufficient to show that their character was very much the same as that of the fragments discovered at Leeds.

Other notices of the same kind might be quoted, but these will suffice to prove that crosses of this kind were sepulchral memorials. Those of which Simeon of Durham, and William of Malmsbury, make mention, belong to the eighth century, whilst others still in existence must be referred to the seventh, and some of the Leeds fragments, as will appear in the sequel, to the tenth century.

These monuments are generally four-sided columns of stone, tapering gradually from the base to the summit, and when perfect, which is very seldom the case, terminated by a cross, which is generally a separate stone mortised into the shaft. In size they vary from about three feet, (the probable height when complete of an example at Lastingham,) to eighteen or twenty feet high. They were in most instances erected in pairs, one at the head, the other at the foot of the grave. Thus at the head and foot of what is called the Giant's Grave, in the churchyard at Penrith, Cumberland, two crosses, which have suffered very much from time and violence, stand opposite to each other, and the space between them is enclosed by four semicircular stones, two on each side. This monument is a christianized form of that which was in use amongst our forefathers before their conversion, the rude pillars of stone of the earlier times being represented in later times by the cross. Thus two pillar stones on the coast, four miles north of Whitby, are said to mark the grave of a chieftain of pagan times named Wada; and their distance apart, twelve feet, has given rise to a tradition, like that at Penrith, that he was a giant.

The description which Snorro gives of the tomb of King Harold, in his "Chronicles of the Kings of Norway," is that of a monument resembling that at Penrith in every respect, except that simple pillars, instead of crosses, stood at the head and foot of the grave. "King Harold was "buried in the middle of the mound, a stone being placed at "his head and another at his feet, and the sepulchral stone "placed over him; lesser stones being also added at the "sides."

At Sandbach, in Cheshire, a more curious arrangement is to be seen, where two crosses, each on a separate plinth, stand together on an irregular four sided basement, at the corners of which are smaller pillars, and the whole on another basement.

Their ornamentation consists of statuary, either single figures of Our Blessed Lord and His saints, or the person to whose memory they were raised, or of groups of figures representing events in Sacred History; of convoluted scrolls with foliage and fruit, and sometimes animals introduced; of interlaced ribbon patterns, of great variety, and sometimes of great intricacy of design; of frets; and of animal and human figures monstrously distorted, and interwoven with one another. Sometimes the opposite sides of a cross are occupied with continuous scrolls, and the others by a succession of panels, in which are either subjects in arched or oblong compartments, or interlaced patterns. The style of these ornaments, and the character of their workmanship, varies very much; and we have not as yet sufficient evidence to warrant us in assigning to each period its peculiar style; but this much may be said, that most of those which are the earliest, and which must probably be referred to the seventh century, are superior in the treatment of the human figures upon them, whilst they are, perhaps, inferior in the designs of their scrollwork and interlacing to others which are certainly of later date, and to some of the same period; and the reason for this is to be assigned to the fact that there were two distinct schools of art in Northumbria, the Roman, introduced by St. Paulinus and his brethren, and again by St. Wilfrid, nearly forty years later; and the Irish, introduced by St. Aidan and the missionaries from Hü. This conjecture is confirmed by comparison of the MSS., written by these two schools. Of the Roman School there is a fine example in the psalter of St. Augustin, among the Cotton MSS. in the British Museum. The writing is either that of an Italian, or of one who had been trained by an Italian master; the figure of the Psalmist at the head of the book is almost classical in design, and so are some of the ornaments, whilst others, particularly in the borders and the initial letters, approach more nearly to those of the Northumbrian Irish School.* In the Irish MSS., on the contrary, and in those written in England by the Irish school of Lindisfarne, in the seventh and eighth centuries, nothing can exceed the perfection of the scrolls, frets, and interlacings, and scarcely anything the barbarity of the attempts to delineate animal and human forms. So on the earliest crosses to which we can assign a date, the fragments at Dewsbury and the crosses at Bewcastle and Ruthwell, the representations of human figures are very respectable. The former probably belong to the school of art established by the first missionaries, St. Paulinus and his brethren; the latter belong to the time when St. Wilfrid's influence prevailed in Northumbria. On the fragments of a later cross, found at Alnmouth, in Northumberland, on which the Irish artist, Myredeh, has inscribed his name, the human figures are very rude.

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* The Irish and the Anglo-Saxon Schools of Ornament had, of course, a common origin, for St. Patrick was trained, for the work of his apostleship in Ireland, at Tours under St. Martin, at Rome, in the islands of the Mediterranean, and then at Auxerre under St. German. So if we find in the Kentish MSS. ornaments similar to those which were employed in the illumination of MSS. at the same time in Ireland, we can only regard both as developments of the same original style.

The inscriptions which remain upon some of these crosses are our only certain guide in determining the period at which they were erected, and a comparison of the workmanship of these, will assist us in forming conclusions as to the age of others.

I have already alluded to the fragments at Dewsbury. These, however, seem to have belonged rather to a memorial cross, than to a sepulchral monument; but of course it is impossible to speak with certainty on this point, since an inscription commemorative of an event in the history of the place, might have been placed on a monument to the memory of some person departed. However, Leland tells us that he saw at Dewsbury a very ancient cross, on which was an inscription—"Paulinus hic celebravit et prædicavit;" and an old ballad, in which a former Vicar of Dewsbury records the ancient glories of his parish, mentions this cross, with the additional information that it was carved with figures of the Apostles:

"In the churchyard once a cross did stand,
"Of Apostles sculptured there;
"And had engraven thereupon,
"'Paulinus preached here.'"

These notices seem to have been confirmed by the discovery some years ago, in the course of repairs of the church, of several sculptured fragments, which there is reason to conclude are remains of this famous cross. For the subjects of the carving seem to be, on one fragment, our Blessed Lord; and on another, His Apostles; and above the head of Our Blessed Lord, on the former, are the words IHS XRVS, "Jesus Christus;" and on the other are two lines of an inscription, which, though imperfect, is, like that recorded by Leland, in Latin, and in the narrative form. The upper line is inscribed —VMFECITEPA, and the lower—BETDVOPIS. It is, of course, very difficult to interpret inscriptions so fragmentary as these are; yet VM is evidently the termination of the accusative case of a word, governed by "FECIT," and "EPA" is a proper name, still preserved in the names of villages in the West Riding, Hepworth and Heptonstall; BET can only be the ending of some such word as "habet;" and "DUOWIS," (the fourth letter being the Anglo-Saxon W,) is the beginning of the name of Dewsbury. Supposing then these stones to be fragments of the celebrated cross of St. Paulinus, I would suggest that this inscription may be a continuation of that which Leland mentions, and that it may be a record of the conversion by St. Paulinus of the lord of Dewsbury; and I would supply five letters at the beginning of each line of the inscription as we have it, which is about the number that the loss of a figure at the left hand of each group of carving indicates are wanting, and taking the inscription mentioned by Leland in connection with it, would suppose that the whole may originally have stood thus, in six lines:

IHS XRVS
SCSPAVLINVS
HICPRAEDICAVIT
ETCELEBRAVITET
XRANVMFECITEPA
QVIHABETDVOWIS

and read the whole inscription thus:—"Jesus Christus. Paulinus hic prædicavit et celebravit et Christianum fecit Epa qui habet Duowis." "Paulinus preached and celebrated (i.e., the Holy Eucharist) here, and made Epa, who possesses Dewsbury, a Christian." Now there was, about this time, and probably in Northumbria, a prince named EPA. We have a rather extensive series of coins on which this name appears. In Ruding, on several coins, Plate 2, figs. 9, 10, 13, 16, 17, we read distinctly, in Runic characters, EPA. A coin in the collection of the Leeds Philosophical Society, and several others in other collections, have ÆPA. So remarkable a series of coins agreeing in giving the name Epa or Æpa, leaves no doubt that there was a prince of this name; and their great resemblance to one in the collection of Mr. Lindsay, of Cork, which there is every reason to believe is of Oswiu, king of Northumbria from A.D. 642 to 670, helps us to determine the period at which he lived. About this time there was a prince, brother of Penda, king of the Mercians, who, in the Saxon chronicle, is called *Eawa*, and in the genealogies at the end of the chronicle of Florence of Worcester, *Eoua*, and *Eowa;* but in Florence's chronicle itself, *Eoppa*, in that of Henry of Huntingdon, *Epa*, and in the Annals of Cambria, *Eoba*. The reason of this difference is of course the resemblance between the Anglo-Saxon W and the letter P. He fell in the same battle as St. Oswald, A.D. 642, and if he be the same as *Epa* of the Dewsbury inscription, would, no doubt, as being a Christian, be on the side of St. Oswald, opposed to his brother. Most of the coins above mentioned are marked with the symbol of Christianity.

There can be little doubt, however, in assigning this inscription at Dewsbury to the earliest period of Northumbrian Christianity, whether this be his memorial or not.

At Collingham, there are fragments of three or four crosses, and of these, one about five feet high, is in a style of art very much resembling that of the Dewsbury fragments, and probably of equal antiquity. It presents on each side three figures of saints, in arches, one above another. The lowest series is separated from the two upper by a band of scrollwork, which follows the line of the arch. The attitude of the figures is varied, some being full faced, others turned a little to one side; and there is this difference between the broad and narrow faces of the stone, that on the former the figures are of larger proportions and only half-length, on the latter they are full-length and smaller. This very interesting and early example shows no marks of the Irish School of Art.

The second fragment is one limb of the head of a cross, with knotwork on each side of it. It has been fitted to the stone beneath it, but the patterns are not continuous, nor is it so broad.

The third fragment has a simple fret on the two narrow sides, an interlacing ornament on the back, and on the front an ornament not unlike one of those on the Bewcastle cross, formed of two branches interlacing with fruit and foliage.

The fourth fragment has on the back a knot, and traces of an inscription in two lines :—

+ ŒDILBLÆD
————TÆ

on the second side a spiral scroll with flowers and two lines of an inscription, of which the first line is quite distinct, the second presents only faint traces of letters

ÆFTÆRG
N—F——B;

on the front a knot and a device formed by two monsters intertwined, and beneath an inscription of which the first line is distinct as before, and the second faint; it seems to be

AUSWINIC
YNINGGIC;

on the fourth side a simple interlacing pattern, and an inscription almost defaced, of which the most distinct letter is an S at the beginning of the second line. Fortunately the traces of the inscription, even where it is most defaced, are sufficient to show that it was in the same form as those which will be noticed in the sequel, and by comparison with them it is not difficult to restore the whole thus :—

+ŒDILBLÆD	ÆFTÆRGI	AUSWINIC	EGÆDDE
THIS SETTÆ	NIFÆYMB	YNINGGIC	RSAULE

that is, two couplets of alliterative verse :—

+Œdilblæd this settæ	Œdilblæd this set
æftær ginifæ	after her nephew
ymb Auswini cyning	after Auswini the king
gicegæd der saule	pray for the soul.

The name Œdilblæd which I have supplied at the commencement, and which seems to agree with the traces of letters that remain in the first line, is not mentioned in history as connected with Oswini, nor is any person who stood in that relation to him. The spelling of both names is singular, and indicative of early date. Indeed there can be no doubt, I think, as to the identity of the person whom this monument was designed to commemorate. It is Oswini who reigned in Yorkshire from A.D. 642 to 650. During the later years of his reign he had been at enmity with Oswiu, the son of St. Oswald, king of Bernicia; and at last their forces met at a place which Venerable Bæda calls Wilfaræsdun, and which he says is ten miles north-west of Cataracta. Here Oswini, seeing that Oswiu's forces were far superior to his own, determined to avoid an engagement which could only result in the slaughter of his people, and accordingly dismissed them to their homes, himself retiring in company with a trusty soldier to the abode of Earl

Hunwald, in Gætlingum, to whom he had given not only that place but other lands besides, and from whom, on account of these past favours he now claimed hospitality; but the Earl forgot the duty of gratitude to his benefactor, and abused the confidence reposed in him. He repaired to Oswiu, and made him acquainted with the retreat of Oswini, and Oswiu immediately sent Ethilwini, his steward, with a band of soldiers to the place, with orders to put him to death. Thus perished, on the 20th of August, A.D. 651, the holy king Oswini, in the ninth year of his reign. Eanflæd, the wife of Oswiu, a relative of Oswini, obtained from her husband a grant of land in the neighbourhood, and gave it to Trumheri, their kinsman, that he might found thereon a monastery, in which prayers might be continually offered for the souls of Oswiu and Oswini. He had been educated amongst the Scots, became the first abbot of this monastery, and was afterwards the third bishop of the Mercians. The body of St. Oswini rested here for a time, and was afterwards translated to Tynemouth, and interred in the cemetery there.

The scene of this murder has generally been supposed to be Gilling, near Richmond, and indeed is identified with it in Capgrave's life of St. Oswini, but there is nothing in earlier writers to warrant this, and I suppose that the writer of this life was misled by the fact of the proximity of Gilling to Catterick. There is, however, no need to fancy such a proximity to the place where Oswini disbanded his forces and fled; nay, it seems more probable, that, reserving himself, as Venerable Bæda says, for better times, he would place as great a distance as possible between himself and the army of Oswiu. Moreover, I feel quite convinced that the meeting of the rival kings did not take place near Catterick, for the name is given quite distinctly Wilfaræsdun, and there is no such place at the required distance from Catterick, nor I believe in Yorkshire at all. There is Diderston, but the dissimilarity of the names is so great, that it is impossible to identify it with Wilfaræsdun; and on the borders of Yorkshire and Cheshire is Wilber Clough, but no place resembling Catterick in name near it. In Northamptonshire, however, there is Wilbarston, about eight miles north-west of Kettering, and this I feel satisfied is the place, and believe that Venerable Bæda must have confounded Kettering with Catterick in the information that was given to him relative to the scene of this meeting. It may be objected that Wilbarston and Kettering are not within the limits of the ancient kingdom of Northumbria. To this I would reply, that at the period when these events took place, the kingdoms of Northumbria and Mercia were not defined by the limits which they afterwards had. Mercia, originally a small state, was rising at the time into greater consequence under the first of its kings who plays any part in history; for of his predecessors, except the first Offa,* we know nothing more than the names. In the genealogies appended to some copies of Nennius, we read "Penda reigned ten years; he first separated the kingdom "of the Mercians from the kingdom of the Northumbrians." This indicates that Penda's declaration of independence was A.D. 645, ten years before his death, but his kingdom must have been very limited in extent at first. The dominions of Ædwini had extended even to the frontiers of the West Saxon Kingdom, as is evident from the story of Cwichelm's attempt upon his life, and his subsequent invasion of Wessex, which could scarcely have taken place at a later time, when the powerful kingdom of Mercia intervened between it and Northumbria: and what we read of the missions of St. Paulinus in Lincolnshire and Nottinghamshire, shews that these districts were subject to Eadwini's authority.

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* That Offa did reign in part of what was afterwards the kingdom of Mercia, about the beginning of the sixth century, though it is doubted by some persons, I hope to have an opportunity of proving at some future time. I feel perfectly satisfied that such was the fact.

To his territorial empire St. Oswald succeeded, and as his character will not allow us to suppose that he was the aggressor in the conflict in which he lost his life, the place of his death, (generally and most probably supposed to be,) Oswestry, in Shropshire, must have been within his dominions. Later, when Oswiu, by the murder of St. Oswini, had added to his kingdom of Bernicia the rest of the dominions of St. Oswald, we find him exercising authority over great part of what was afterwards the kingdom of Mercia, and committing the government of the provinces south of the Humber to Peada, the son of Penda; and when, in 658, the Mercians chose Wulfhere for their king, it is said to have been an act of rebellion against his authority. A.D. 660, we read of Alcfrid, the son of Oswiu, and king of Deira under him, granting lands at Stamford, in Lincolnshire. A.D. 679, this province was severed from the Northumbrian kingdom; and from this time forward under Ethelred, Ethelbald, and Offa, Mercia gradually advanced until it became, for a time, the most important of all the Anglo-Saxon kingdoms.

These facts are sufficient to prove that, in the time of St. Oswini, the kingdom of Northumbria did comprehend the district in which Wilbarston and Kettering are situated. In Wilbarston, then, I believe I have found the Wilfaræsdun of Venerable Bæda. It is but natural to suppose that St. Oswini would retreat in the direction of his own residence, which was most probably near Leeds; but as this would be the immediate object of the army of Oswiu pursuing him, he sought shelter in the house of Earl Hunwald, until the danger should have passed away; and the discovery of his monument proves, what independently we might have regarded as probable, that the abode of the Earl was not far from his own residence. For it seems to prove that Collingham is Gætlingum, the place where St. Oswini was murdered, where his body rested for a time, and where a monastery was erected in expiation of the crime of Oswiu. The name, certainly, bears as great a resemblance to that of Gætlingum as Gilling, and, indeed, a greater, as the analogy of Cuneningum, also mentioned by Venerable Bæda, which is now Cuningham, shows; but, indeed, the claim of Gilling to be regarded as the scene of these events seems to be quite set aside by the discovery of the true situation of Wilfaræsdun.

During the reign of St. Oswini, the influence of the Scottish missionaries was predominant in Northumbria. Of the friendship between him and St. Aidan, Venerable Bæda gives us a beautiful story; and Trumheri, the first Abbot of Gætlingum, was educated amongst the Scots. So on this cross we observe only the ornaments, which I have supposed characteristic of the Irish School of Art; scrolls and knots and monstrous animals, without any attempt to delineate the human figure.

The next monument to which I shall direct attention, is one which I believe to have been executed not many years later, but under the influence of a different school. It is at Bewcastle in Cumberland, and has been already more than once referred to. It is of larger dimensions than that at Collingham can have been when perfect, being 14 feet 6 inches high, and still stands in its original position, fixed in an irregular octagonal plinth. It presents on the western face, beneath an imperfect inscription, an effigy of St. John the Baptist, pointing with his right hand to the Lamb of God, whose symbol rests on his left arm; then an inscription in Runes, in two lines, the names of Our Blessed Lord,

+GESSUS
CRISTTUS,

a majestic figure of whom is beneath, in an arched recess, holding a scroll in His left hand, giving His blessing with His right, and trampling on demons personified by swine. Then follows an inscription of nine lines :—

+T̅H̅IS SIGBEC
UNSETTÆH
WÆTREDIM
GÆRFÆBOLD
UÆFTÆRBARÆ
YMB CYNING
ALCFRIDÆG
ICEGÆDDE
OSUM SAULUM

commemorative of the king for whom this monument was erected, and of whom the effigy in profile is beneath in an arched recess, holding a hawk in his left hand above a perch. The eastern face presents a continuous scroll with foliage and fruit, and monsters, quadrupeds and birds introduced, feeding upon it.

On the northern side, we have in Runic letters, nearly six inches long, the Holy Name +GESSU, then a scroll, then an inscription, OSLAAC CYNING; then a knot, then a second inscription, WILFRID PREASTER; then an oblong space filled with chequers, then a third inscription, CYNISWID; then another knot, then a fourth inscription, CYNIBURUG, and lastly a double scroll.

On the southern side, at the top, we have first, the beginning of the name CRISTUS corresponding to GESSU on the north. Below this is a knot, an inscription, EANFLÆD CYNGN, then a scroll, in the midst of which a dial is introduced; a second inscription, ECGFRID CYNING; another knot, a third inscription, CYNIBURUG CYNGN, another scroll, a fourth inscription, OSWU CYNING ELT, and a third knot.

Now these inscriptions enable us to ascertain exactly the age of this monument. The long inscription contains three couplets of alliterative verse:—

+This sigbecun	This beacon of honour
settæ Hwætred	set Hwætred
im gærfæ boldu	and carved (this) monument
æftær baræ	after the ruler
ymb cyning Alcfridæ	after king Alcfrid
gicegæd deosum saulum	pray for the souls.

and commemorates Alcfrid, the eldest son of king Oswiu, who reigned in Deira from about A.D. 655 to 664; and the other inscriptions give us the names of his father, "Oswu cyning elt," i. e. Oswiu King the elder; of his brother, "Ecgfrid cyning," of his uncle, "Oslaac cyning," of his stepmother, "Eanflæd cyningin," of his wife, the daughter of Penda, "Cyniburug cyningin," of her sister, "Cyniswid," and of his friend St. Wilfrid, "Wilfrid preaster," elected, through his influence, Bishop of York, A.D. 664. This election was probably one of the last acts of Alcfrid's life, and his name never appears again in history. The date of this monument, then is clearly fixed in the year 664.

Mr. Hemingway, of Dewsbury, has in his possession a fragment which evidently formed part of the head of a small memorial cross, on which is the following inscription, perfectly legible:—RHTAE BECUNAEFTER BEORNAE GIBIDDADDER SAULE, i.e.

	(N. this set
rhtae	after ——) rht
becun aefter beornae	a beacon after his son
gibiddad der saule	pray for the soul.

In the Museum of the Society of Antiquaries of Newcastle-on-Tyne, there is a fragment on which is an inscription quite perfect, and written in Roman minuscules, as well as in Runes, the only example that has yet been found of such

a double inscription. Correcting, by means of each copy, the errors which occur in the other, the reading is—
+EOMÆRTHŒSŒTTÆÆFTÆRHROETHBERHTÆBECUNÆFTÆRE OMÆGEBIDÆDDERSAULE, i. e.,—

+Eomær thœ sœttæ	+Eomær this set
æftær Hroethberhtæ	after Hroethberht
becun æftær eomæ	a beacon after his uncle
gebidæd der saule	pray for the soul.

A fragment of a cross was found in 1774, between Wycliffe and Greta-bridge, inscribed in Roman uncials :—

BAEDA
—— T—
AEFTE
RBERC
HTVINI
BECUN
AEFTERF

Bæda (the set) t (æ)	Bæda this set
æfter Berchtuini	after Berchtuini
becun æfter f(adoræ	a beacon after his father
gibiddad der saule)	pray for the soul.

These three examples are apparently all later than the Bewcastle monument, but not much later than the beginning of the eighth century.

At Hackness, near Scarborough, there are three fragments of crosses, on which are Latin inscriptions to the memory of abbesses who presided during the first half of the eighth century over the monastery founded there by St. Hilda, A. D. 679 ; and in the Museum at Manchester, a complete cross which formerly stood in the churchyard at Lancaster, on which is the following simple inscription in Runes :—GIBIDÆT̅H̅ FORÆ CYNIBALT̅H̅ CUDBEREHT, " Pray for Cynibalth and Cuthberht."

We have, thus, in the names of historical interest which some of these monuments supply, in their inscriptions, in the early forms of the language in which these inscriptions are written, as well as in their peculiar style of art as compared with that of illuminated MSS., abundant evidence to prove that most of these monuments belong to the seventh and eighth centuries; and there can be no doubt that it is to such monuments as these, that the notices cited above from our early historians apply. We may now proceed to notice, in detail, the fragments of similar monuments discovered at Leeds. These were:—

1. A curious fragment, with an interlaced pattern on the side, and a cross in a circle on the top. This, of course, has not formed part of a cross, but I have no doubt that it is the corner of an altar, the sides of which were ornamented with similar work, and which, perhaps, had five crosses on the top. At San Ambrogio, Milan, I remember having seen a stone similarly ornamented, and which at the time I believed to be an altar of the sixth or seventh century.

2. A fragment of a small cross, with scrolls and interlacing ornaments on its adjoining sides.

3. Fragments of the heads of two small crosses, one of which may have belonged to the last mentioned. These are of very different workmanship from, and I believe of earlier date than, the following.

4. Fragments, nearly completing a large cross, which, when perfect, must have been nearly 13 feet high. These present on what we may call the eastern face, a saintly personage, distinguished as such by the glory (of a form common in illuminated MSS. of the Irish School, and found also on some early Saxon coins,) around his head, then a figure with a book, and then a curious device of a winged figure, a demon in the act of devouring a human being whom he holds by the hair and the skirt, and who seems to hold up his hands in supplication to the figure above. Below are three symbols—a spear head, a hammer, and forceps. On

the opposite side, we have first an interlaced pattern, then a half human figure across which, apparently, are the paws of a lion; another interlaced pattern, and a figure with a sword in his right hand and a hawk on his left shoulder. Scrolls and knots of different designs occupy the remaining sides.

5. Fragments of another very similar cross, on one of which is an imperfect inscription:—

CUNI—
ONLAF

6. Fragments of another, distinguished from the last by having a cabled border within the frame.

7. Fragments of a sixth.

The resemblance between the fragments 4 and 5, is so great, that I think it extremely probable that the latter belonged to a second cross, which with the former marked one sepulchre; and that, the sepulchre of the king whose name and title are inscribed upon one of the fragments. There can be little doubt that the last letter of the first line of this inscription is part of the Runic U, and that the word complete would be CUNUNC, the form which occurs upon the coins of Anlaf, Sitric, and Regnald. CUNUNC ONLAF then, is "King Onlaf." As there were two kings of this name who reigned in Northumbria in the tenth century, a brief examination of their history will be necessary in order to ascertain to which of them this monument belongs.

A.D. 927, immediately after the death of Sitric, Æthelstan expelled his sons Anlaf and Guthfrith, and the former fled to Ireland.

A.D. 937, Constantine, King of Scotland, persuaded Anlaf, his son-in-law, who had conquered Dublin and established his kingdom there, to assist him in invading England. Accordingly he entered the Humber with a large fleet, and landed in Lincolnshire; but was soon afterwards attacked by Æthelstan and his brother Eadmund, and utterly routed at Brunanburh, (now Burnham.) Five kings and seven princes were killed in the battle, and Anlaf and Constantine compelled to take to their ships.

A.D. 940, the same Anlaf returned with a large fleet, landed in Yorkshire and took possession of York. Thence he marched southward, intending to subdue the whole kingdom. At Leicester he was met by King Eadmund, and after a battle in which both sides suffered great loss, a treaty of peace was concluded between them, in which it was agreed that Anlaf and Eadmund should divide the kingdom, Anlaf retaining the north and Eadmund the south, that the Watling Street should be the boundary of their respective dominions, and that the survivor should have the whole of England.

A.D. 941, Anlaf, who had recently obtained the royal dignity, wasted Tiningham and burned the church of St. Balthere there; but, visited immediately by the judgment of Almighty God, came to a miserable end. This was a different person from the subject of the foregoing notices, for Simeon, of Durham, after mentioning the peace between Eadmund and Anlaf, (which he dates A.D. 939,) says Olilaf wasted Tiningham and perished, and then adds "but Onlaf, the son of Sitric, reigned over the Northumbrians."

A.D. 941, Eadmund invaded Northumbria, and expelled Anlaf, the son of Sitric, and his nephew Regnald, the son of Guthfrith, and took upon himself the government of the whole kingdom. Yet he seems to have been soon after reconciled to them, for A.D. 943, he stood as godfather to both, to Anlaf at his baptism, presenting him at the same time with royal gifts; and to Regnald at his confirmation, adopting him as his son.

So far I have followed the Flores Historiarum of Roger of Wendover, because he gives fuller details respecting these kings; and appears to have been better informed as to their history than other chroniclers, who differ from him with regard to the date of the expulsion of Anlaf and Regnald, placing it in A.D. 944. This however, may have been a second expulsion, for Henry of Huntingdon, says that in the first year of Eadred, A.D. 946, Anlaf, who had been expelled from the kingdom of Northumbria, returned with a great fleet, and was received with great joy by his people and restored to his kingdom, which he held with great power for four years; that, however, in the fourth year the Northumbrians rebelled against him, and chose for their king, Eric, the son of Harold. The Saxon Chronicle corroborates these circumstances, but places the dates somewhat later; for after stating that, A.D. 947, the Northumbrians swore fealty to Eadred, but shortly after broke their oaths, and chose Eric for their king; and that, A.D. 948, Eadred ravaged Northumbria, and forced the people to abandon Eric; it says that, A.D. 949, Anlaf Cwiran came to Northumbria, and that, A.D. 952, the Northumbrians expelled king Anlaf, and received Eric, Harold's son. The surname Cwiran, here given to Anlaf, does not indicate a different person; it is one which was given to him in allusion to his constantly returning after every defeat and expulsion. After mentioning his deposition by the Northumbrians to make way for Eric, Henry of Huntingdon adds, "he again for a short time held the kingdom," and this statement the inscription on the cross at Leeds confirms: for all the notices in the Chronicles appear to relate to Anlaf, the son of Sitric, except that of the year 941, which mentions an Anlaf destroying Tiningham, and dying soon after; and as his death probably occurred in that neighbourhood, and there is no ground for supposing that he was a Christian, I feel satisfied that this fragment preserves the name of Anlaf, the son of Sitric, who certainly was a Christian in his later years, and indicates the place of his death and burial.

Eric was killed A.D. 952, (or 954 according to the Saxon Chronicle,) by Maco, son of Onlaf, therefore, very probably, the son of this king. The death of Eric paved the way for his resuming the kingdom; but his reign must have been of very short duration, for in the same year Eadred obtained the kingdom of the Northumbrians, and all England was thenceforward united under one sovereign. That year, then, we may safely regard as the period of his death, and the erection of this monument.

So remarkable a collection of fragments of sepulchral monuments of different dates, (and it is believed that the number actually found was even greater still,) indicates the existence, in early times, of a considerable religious establishment on the site of the Parish Church of Leeds; and of such an establishment we seem to have two notices, which, owing to some blundering in the spelling of the names, have been hitherto overlooked. In the life of St. Gildas, who lived in the fifth century, it is said that his brother Mailoc, after being instructed in sacred learning, came to Luihes, in the district of Elmail, and there built a monastery, in which, continually serving God with prayer, praise, and fasting, he rested at length in peace. I believe that a mistake of one letter has been made in each of these names, and that for Luihes and Elmail, we should read *Luides* and *Elmad*, i.e., Leeds and Elmet. The extent of the district of Elmet in ancient times may be learned from an ancient Anglo-Saxon MS., published by Gale, in which it is said, "Elmedsætna continet sexcentas hidas," and as the hide signified land under cultivation, and most of this district was forest, this computation indicates an extent which will warrant us in believing that Leeds, which is about twelve miles from

Sherburn-in-Elmet, and seven from Barwick, may very well have been comprehended within its limits; and as there does not appear to be any other place which will agree with the terms of this notice in the life of St. Gildas, we may safely conclude that the monastery which St. Mailoc founded in the fifth century, was here. Again, Simeon of Durham, tells us that Eanbald, Archbishop of York, died in the monastery which is called Etlete, August 10, A.D. 796. Roger of Hoveden, gives the name Æt Læte, showing that in this, as in many other instances, (such as Æt Corabrige for Corbridge, Æt Stanforda for Stamford,) Æt is merely the preposition prefixed, and that the name is Læte; and there is no place but Leeds which will answer to this name. Here, then, Eanbald died, and from this monastery his body was conveyed in solemn procession to York for interment.

The probability being admitted that Leeds is indicated in both these notices, we seem to gain a clue to the situation of "the monastery of the Venerable Abbot Thrydwulf, in Elmete Wood," of which Venerable Bæda speaks, and where, he says, that to his day the altar was preserved, which, because it was of stone, had escaped the fire which destroyed the palace of Ædwini "in Campo Dono," and the church which St. Paulinus had erected within its precincts. Indeed the context makes this probability greater. The altar, and whatever could be saved from the fire, was, of course, royal property; and as it may be regarded as certain that the royal family of Northumbria, after the destruction of their first residence, established themselves in this neighbourhood, we may conclude that the monastery in which they placed the altar was not far from their new abode.

That Leeds was the place to which the royal family retreated, after the death of Ædwini and destruction of his palace, we learn from Venerable Bæda, who tells us that the succeeding kings, that is, Osric and Oswald, built for themselves a palace "in regione quæ vocatur Loidis." + The names Coneyshaw and Coneygarth, (the king's wood and enclosure,) and the remains of trenches, existing until the last century, led Thoresby to fix upon Osmundthorpe as the site of this palace; and I think there can be no doubt that it was there.

Here then, most probably, resided Osric, St. Oswald, and St. Oswini, and here was residing Oswiu at the time when Penda invaded his dominions, and was overthrown and slain at the decisive battle of Winwædfield. The site of this battle, which has been the subject of many conjectures, may, I think, be accurately ascertained by comparing Venerable Bæda's account of it with what is stated in the Early British Chronicle, appended to some MSS. of Nennius.

The former may be briefly summed up as follows:—Penda, king of the Mercians, had invaded the dominions of Oswiu, and Oswiu, unable to contend with him, offered him an exceedingly great ransom, on condition of his returning home. Penda, bent on the entire subjugation of Northumbria, rejected his offers; and Oswiu, relying on the help of God, determined on resistance; and though his force was but small, and the army of Penda consisted of thirty legions, led by as many princes renowned for their bravery, he gave him battle near the river Winwæd. At the beginning of the engagement the pagan army was routed, Æthelhere, King of the East Angles, and most of the princes who were on Penda's side were slain; and more perished in the river, which had over-flowed its banks at the time, than perished by the sword. It is afterwards said King Oswiu concluded the aforesaid war in the region of Loidis, that he cut off the head of Penda, and converted the Mercians to the Christian faith.

+ [illegible]

Let us now examine the British account. It is contained in a short but valuable chronicle, principally consisting of genealogies, appended to four MSS. of Nennius.

The first of these MSS., of the tenth century, 3859 in the Harleian Collection, contains Nennius, these genealogies, the Annals of Cambria, and the Genealogy of Hoel Dha. The other three, in the Cottonian collection: Vespasian D. XXI. 1, and B. XXV. 7, both of the twelfth century, and Vitellius XIII. 11, of the thirteenth, contain Nennius and the genealogies only. These three agree very closely with the first, but as they omit the Annals of Cambria and the Genealogy of Hoel Dha, they would seem to be copies of some common original in which these were not. Where, then, they agree in differing from the earlier MSS., we may place more confidence in the reading they supply than in that given therein, and, generally, the spelling of the names is more correct in the two twelfth century MSS. than in the earlier one. Now, all these MSS. agree in the following account of Penda's war with Oswiu. (In the original the paragraphs are transposed, the first being placed second. This obvious error I take the liberty of correcting):—

"Osguid sent all the wealth which was with him in the city to Manu, to Penda, and Penda distributed it to the kings of the Britons, that is, 'Atbret Iudeu,'" (the ransom of Iudeu). "Osguid killed Pantha in the field of Giti, and the kings of the Britons were slain who went out with King Pantha in his expedition to the town which is called Iudeu."

The Annals of Cambria, in the first of these MSS. contain the two following notices:—

CCXII. year (A.D. 656).—The slaughter of the field of Gaii.

CCXIII. year (A.D. 657).—The execution of Pantha.

The account given in the two paragraphs above differs from that in Venerable Bæda, in saying that Oswiu actually gave the treasures, and that Penda divided them amongst his allies; whereas he says that Oswiu offered and Penda refused them. I prefer the former, and believe that Penda accepted the ransom, but refused to make peace; and that Oswiu, driven to desperation, collected his forces, and by the suddenness and impetuosity of his assault gained the victory. Of the identity of Iudeu with Loidis there can be no doubt. The error in the first letter of the name has arisen from the great similarity of the letters *l* and *i* in the MSS. of the period to which the original of the British story belongs, *i.e.*, the eighth century.* The place where Penda's forces were encamped is called in the earliest MSS. Manau, in the others Manu; this difference is of slight importance. The scene of the battle is called in the first Gai; but in the others Giti. The annals of Cambria give Gaii, but as they are part of the same volume with the first, they can scarcely be considered a separate authority, and I think we are justified in preferring the reading Giti, in which three distinct transcripts of an ancient original agree. This may be for Witi, since not only *Gu*, but *G* also, is constantly written for W; and if it be so, then in Manu and Witi, we have a clear indication of the locality of this battle. Manu, where Penda was encamped, is Meanwood, and Witi is Weetwood, a little farther from Leeds, where, perhaps, his forces, thrown into confusion by the unexpected attack of Oswiu, attempted to make a stand and were defeated. The river which arrested them in their flight is undoubtedly the Aire, and the nearest point to Weetwood on this river is the neighbourhood of Kirkstall,† where, as it appears from a charter in the Monasticon, there was at the west end of the bridge a piece of land called Winnet, corresponding to "Wynnet" and "Wynnod," of two Welsh versions of the "Brut," and to the "Winwæd" of Venerable Bæda. The etymology of the name Winwæd, "the ford of the battle," seems to show that it was not the name of the river, but rather of the spot where the fugitives attempted to cross, and were drowned in the flood. It is remarkable that Speed, in his maps, places the battle-field in the neighbourhood of Kirkstall Abbey. It does not appear what his authority was for doing so, but he was undoubtedly right.

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* The latest notice in these genealogies being that of Eadberht, who became King of Northumbria, A.D. 738. Of the similarity of these two letters a better illustration cannot be given than the single word "*ignobilis,*" copied from the earliest MS. of Venerable Bæda's Ecclesiastical History. *See Plate III.*

† I had fixed upon the neighbourhood of Kirkstall as the probable locality of Winwæd, before I was informed of the letter of Gale to Thoresby suggesting Winnet, and mentioning Speed's conjecture as to the scene of the battle.

The notice in the Annals of Cambria, of the execution of Penda in the year following the battle is valuable, for it explains the statement in Venerable Bæda, who does not say that he was killed in the battle, but mentions his execution as a circumstance subsequent to the date of the conclusion of the war, November 15th, A.D. 655. It would appear that he fell into Oswiu's power, and was beheaded by his orders some months afterwards. The British story is valuable in another respect, inasmuch as it shows clearly, what might, indeed, have been inferred from the other account, that Oswiu was resident in Leeds at the time, and that it was against Leeds, as Oswiu's royal city, that Penda's attack was directed.

The discovery of these fragments having established the fact that Leeds, which had become a royal city in the seventh century, continued to be so until the extinction of the Northumbrian monarchy, and was the burial place of its last king, it may be interesting to mention the existence of a coin, which, taken in connection with the probability that Leeds is the British Cair Luid (or Loit) Coit, and Ludeu of Nennius and Geoffrey of Monmouth, seems to prove that it had, also, what might be expected from its being a royal city, the privilege of a mint. It is one of Sitric, the father of Anlaf. On the obverse it bears a sword, the name SITRC, and LVDO, which can only be the name of a mint. On the reverse we have ERIC MOTI the moneyer's name and title. (See Lindsay's "Coinage of the Anglo-Saxons.")

A notice of two or three monuments, similar to those which have occupied our attention in the foregoing pages, existing in the neighbourhood of Leeds, shall conclude this memoir.

In Raistrick churchyard, there is the base or shaft of a cross two feet four inches high, tapering from about two feet eight inches to two feet one inch, and from two feet four inches to one foot ten inches, with the socket in which the cross was fixed at the top thirteen inches by ten, and nine inches deep. The northern, southern, and eastern sides are each divided by a vertical line into two panels; the first has simple fretwork, the two others have spiral scrolls with foliage. The western side has probably an inscription, but I have not had an opportunity of visiting it, nor have I yet been able to procure a cast which would enable me to decypher it.

On Hartshead Moor, not far from the church, there is the shaft of a cross, called Walton Cross. It stands upon a plinth, is four feet nine inches high, and tapers from three feet six inches to two feet four inches on its broad sides; and from two feet ten inches to one foot eleven inches on its narrow sides. The latter are covered with fretwork; of the former, one has a cruciform device in a circle, and below it a scroll with two birds; the latter has a scroll with four birds, a frame of fretwork enclosing the device on each side. A fragment of the head which had been broken off, and lay by its side for many years, is now at Halifax. The devices on this monument are peculiar, but their character so strongly resembles that of the crosses at Ilkley, that I could fancy them the work of the same hand.

Of these, one has long stood in the centre of the churchyard, the others, at the time of my visit in 1838, were converted to the base uses of stile and gate posts, on the west and south sides of the churchyard. They are now placed all together. The first, which is the most perfect, presents on its eastern face, the symbols of the Evangelists in oblong compartments, human figures in flowing robes, each with the head of the animal which is his symbol, surrounded by a glory, and holding the book of his gospel. Thus, St. John, the uppermost, has the head of an eagle; St. Luke, the next, that of a bull; St. Mark, that of a lion; St. Matthew, as usual, is a human figure. This treatment of the symbols of the Evangelists is peculiar. Instances are known in which they are represented in this way; but they are exceedingly rare, and this is the only instance that has occurred to me.

The opposite side presents the figure of our Lord, and there seems to have been an inscription above His head; then a device composed of two animals whose lower extremities are knotted together, and then another monstrous figure.

The remaining sides have scrolls, with fruit and leaves. The stone in which this cross stands, is still buried in the ground. When it is raised, it will probably be found to have the memorial inscription engraved upon it.

The second cross, which is very much defaced on one side, and worn on the others, is tolerably perfect for about two feet of the lower part, where it has been fixed in the ground. It presents first, two men facing each other, then two animals with their lower extremities interlaced, then two others, and lastly two birds, treated in the same manner as on the Walton Cross. The remaining two sides, for the fourth is mutilated, have scrolls of designs similar to those on the first, with which, indeed, this may have formed one monument.

PLAT

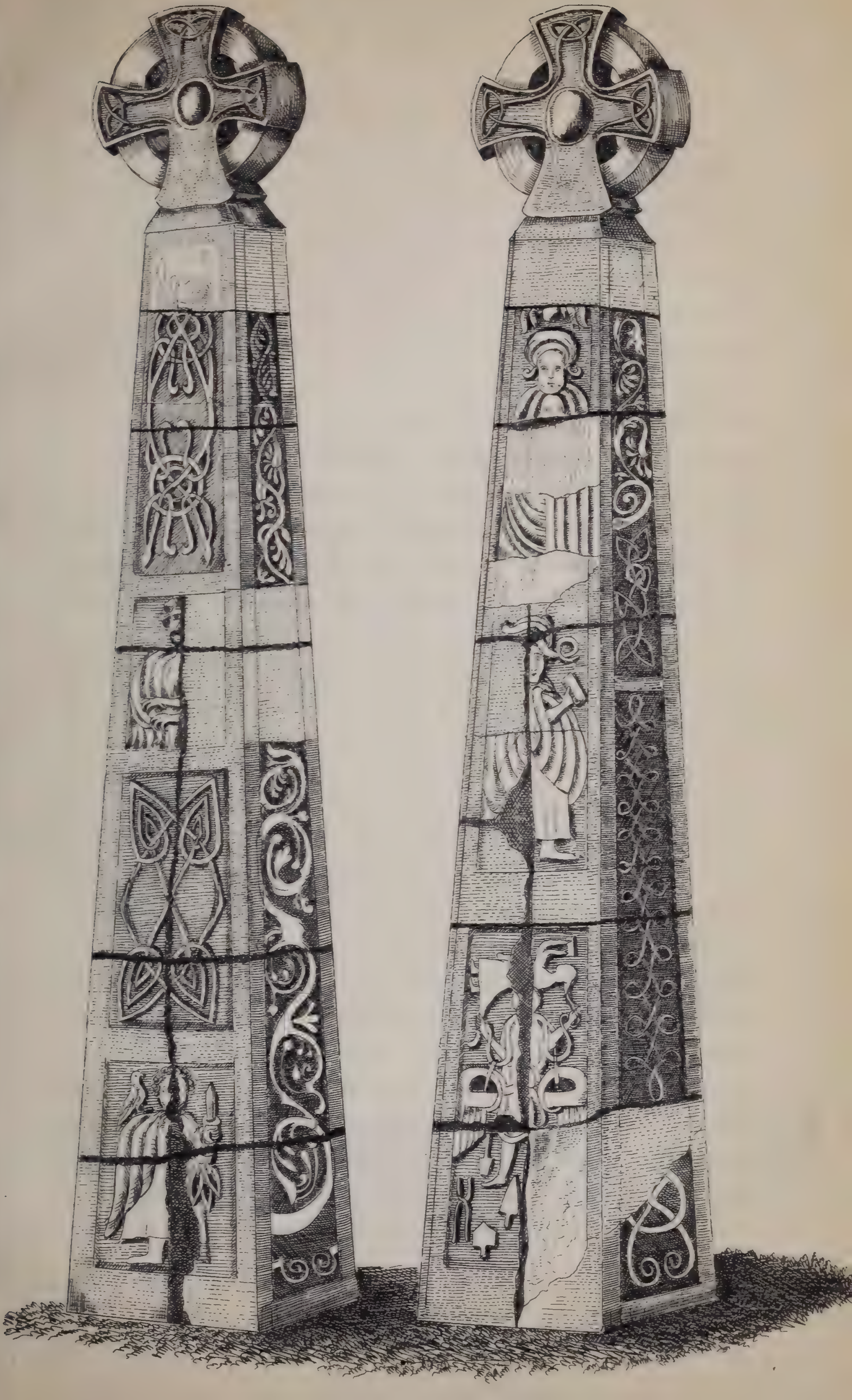
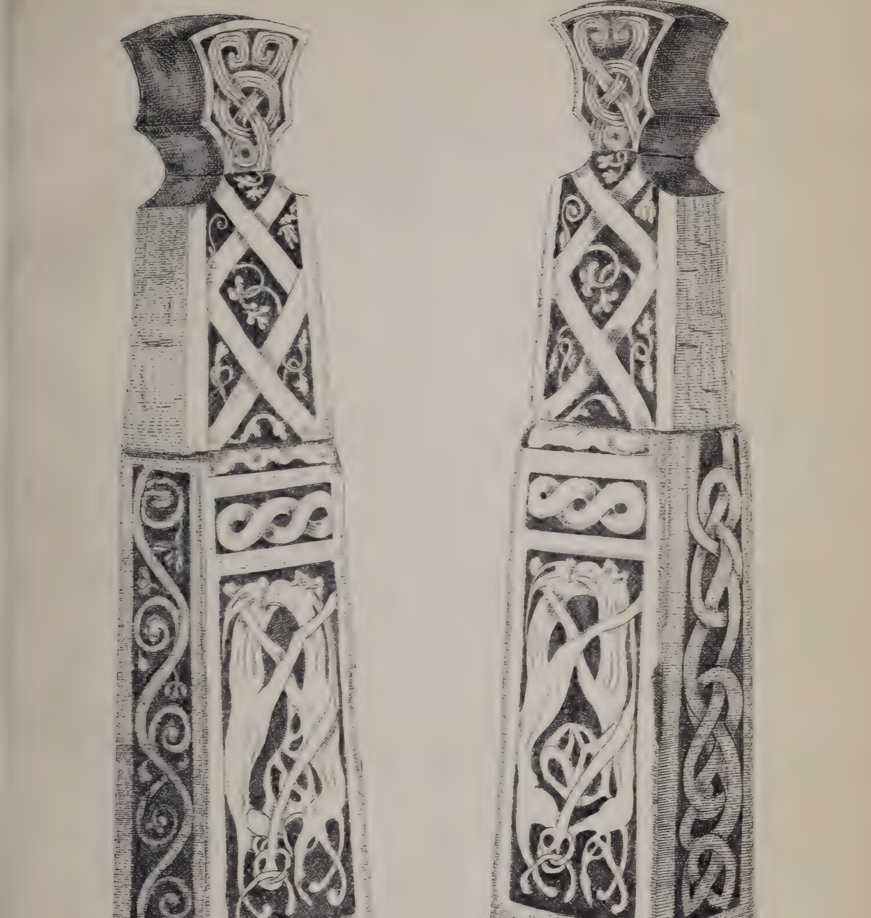


PLATE 2



Cross at Collingham

Dewsbury

IHZXRVZ

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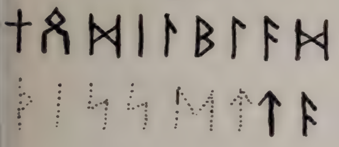
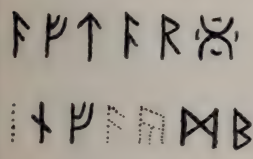
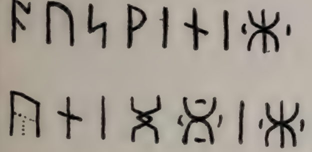
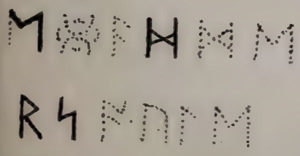
Collingham









ʒnobilir

Runic Northumbrian Alphabet

figure	name	power	figure	name	power
ᚠ	fech	F	ᛟ	œdil	Œ
ᚢ	ur	U	ᚪ	ac	A
ᚦ	thorn	TH	ᚫ	æsc	Æ
ᚩ	ôs	O	ᚣ	yr	Y
ᚱ	ræda	R	ᛠ	ear	EA
ᚳ	cen	C	ᛡ	ior	IO
ᚷ	geofu	G	ᛢ	quern	Q
ᚹ	wyn	W	ᛣ	calc	K
ᚻ	hægil	H	ᛥ	stan	ST
ᚾ	næd	N			
ᛁ	is	I short			
ᛄ	gær	J consonanted sound of Y			
ᛇ	ih	I long			
ᛈ	peord	P			
ᛉ	ilcs	X			
ᛋ	sygil	S			
ᛏ	ti	T			
ᛒ	berc	B			
ᛖ	eh	E			
ᛗ	mon	M			
ᛚ	lagu	L			
ᛝ	ing	NG			
ᛞ	dæg	D			

The third cross has on the eastern side a scroll, and then a figure; and similar designs on the other sides. This is much more worn than the others, and appears to be of different workmanship.

And now in taking leave of a subject which has recalled to memory many pleasant associations of bygone days, I must gratefully acknowledge the courtesy I have experienced, and the assistance I have received during the preparation of this memoir, from R. D. Chantrell, Esq., of London, who kindly supplied me with an accurate drawing of the cross; from Henry Denny, Esq., whose zeal in furnishing information, and taking casts of inscriptions has been indefatigable; and whose interest secured the aid of T. W. Stansfeld, Esq., in procuring photographs of some of these monuments; from the Rev. Thomas Allbutt, Vicar of Dewsbury, who politely afforded every facility for examining and taking rubbings from the remains in his garden; from the Rev. John Snowden, Vicar of Ilkley, who kindly permitted me to remove the masonry which concealed a large portion of an interesting cross in his churchyard; from the Rev. B. Eamonson, Vicar of Collingham, and his niece, Miss Metcalfe, who have also shewn friendly co-operation in the examination of the monuments in their garden; and from F. A. Leyland, Esq., of Halifax, who has furnished valuable information relative to similar monuments in his neighbourhood.

EXPLANATION OF THE PLATES.

Plate I.—Views of the Cross found in the Old Parish Church, at Leeds. The lighter portions shew the parts wanting, the dark lines mark the fractures.

Plate II.—View of one of the Crosses at Collingham.

Plate III.—Restored Inscriptions from the Dewsbury and Collingham Crosses. The word "*Ignobilis,*" copied from the Manuscript of Bæda's Ecclesiastical History. The Runic Northumbrian Alphabet.

OBSERVATIONS ON A CROSS FOUND IN THE OLD PARISH CHURCH AT LEEDS. BY R. D. CHANTRELL, ESQ., ARCHITECT, OF LONDON.

The fragments of this cross were obtained by me as architect, and I paid the labourers for bringing to my Clerk of Works' Office whatever carved stones they found, (which, otherwise, would have been broken up for concrete or fillings of walls,) and, subsequently, they were removed to my residence for examination, and finally to London, to enable me to study its sculptures at my leisure, and consult other antiquaries relative to its peculiarity, and endeavour to ascertain its date. Of the six other pillars, I only obtained one or two fragments of each.

I consider the figure on the cross to be a perfect winged figure with the claws of a bird, the head of a man with short curled hair and a moustache, and most probably represents a cherubim, in allusion to Judaism; on the same side, below, is another figure, with a hawk over the left shoulder;* this figure has also wings, curled hair, and the right hand holds a drawn sword, and a mystic emblem indicative of the mysteries with which the pillar is connected. Between these two figures is an oblong square, the proportion being the first vesica formed by the radius of the circle; this is filled with an interlaced band, composed of four divisions of three vesicas each, threaded by a cross band which unites the twelve divisions; the four great compartments represent the seasons of three months, and the cross band produces thirty intersections, the number of days of the ancient month. So perfectly are the points marked, that the diagonal of one gives the north pole star; and of the other, the Sun in the meridian at the summer solstice; this figure is decidedly astronomic, and has been calculated correctly for its local latitude; the fourth or upper division is composed of two circles, one within the other interlaced by two crossed bands, each terminating in a serpentine form; the stone above it has had those circles repeated, as is proved by the fragment above this last described; this figure relates to the Druidical temples of this country.

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* See Plate I. In consequence of an error in the transfer to the plate, the figures on the Cross are reversed.

Upon the southern edge, at the base, is the figure of a noosed band or rope, and above it, within the same panel, is an interlaced band of twenty-four loops, laid in pairs; these twenty-four interlacings allude to the hours of the day, and from their being so arranged that the bands alternate, they undoubtedly point to the day and night at the equinox; and an oblong panel over this has an interlaced band of seven loops, one of which is circular, two are double pointed, and the four remaining have single points, this points out the seven days of the week, and also the planets visible from the earth; the Sun, Moon, Venus, Mercury, Mars, Jupiter, and Saturn; even to the rounding of the band for the Sun, and the double pointing or horning for the Moon and Venus: these three compartments are mystic and relate to each other; the uppermost panel contains scrolls of foliage, which, directing the eye towards the north, are stunted.

The eastern or most important face contains three large panels: at the base is a male figure horned; his shoulders are surrounded by serpents, and round his loins are bands which elevate two wings; the dexter base is broken off, but on the opposite side, close to his leg, is a spade; below this is a maul, trowel, and clip or forceps; from his head he is in the act of drawing a female figure, long haired, draped and "fully armed," as in both hands she holds an oblong square; the first figure holds her by her hair, which passes between the finger and thumb of his open hand, and his other hand firmly grasps the skirt of her robe; this is emblematic of the birth of Minerva, and alludes to the wisdom of the mysteries:

here we have the tyro in the course of initiation into the mysteries in which he is destined to instruct others; the wings are not elevated to his shoulders, as till instructed he cannot raise himself to his proper elevation; the allusion to the birth of Minerva shews that the brain must be exercised to the utmost, not to allow himself to be *bewildered* by his lesson.

The second figure above this is robed and winged, and represented with the serpent entwined round his head, and holding in his right hand the oblong square more perfected than in the first figure. In this figure the probation is advanced; the wings are on his shoulders, the serpent round his head, the emblem in his right hand; all denoting that the knowledge he has obtained, enables him to soar above the uninitiated.

The third or uppermost figure appears grave; his head encircled by a Nimbus; he is o'ershadowed by the globe, wings, and serpents of Egypt; or a figure representing the Deity of Nineveh, as recently discovered in the sculptures of Nimroud. The uppermost figure has had the middle part chiseled away; this, doubtless, contained the key to the mysteries; the head has the ancient half moon ornament upon it as a glory or Nimbus: the lower part has folds of drapery, but the feet have been destroyed; the Egyptian emblem above the head shews the exaltation of the aspirant to the highest rank or degree attainable.

On the fourth or north side, which requires the spectator to face the south, a continuous scroll rises from the base to the summit of the pillar, the form similar to that of the north, but here luxuriant and flowing.

A keyed wheel cross was found at the same time with the pillar, both carved in millstone grit; three arms of the cross are perfect, but the fourth is broken off; in the centre is a boss or hemisphere, surrounded by a band which forms a triple interlacing on each arm of the cross; this doubtless refers to the Sun in the centre of the universe; the opposite side has a similar device, but slightly indicated, and the bands harmonise with the astronomic figure before described upon the western face of the pillar.

I consider that the cross was placed upon this pillar as upon those of Ireland, Iona, Wales, &c., and it has been stated that similar crosses exist as Monastic in the Crimea.

I have not ventured any theory as to the age of this pillar, and I cannot find any allusion whatever to Christianity, such as appears on many of the later Irish crosses, but there are evidences of the Egyptians, Jews, Druids, Greeks, and worshippers of the Sun.

With regard to inscriptions, many of those in Ireland have had names incised upon them, frequently in such positions as to throw a doubt on their connexions with the original devices of the crosses, some of which existed long before the orate were introduced, and were cut in ignorance of the hieroglyphic legends, intended, like their prototypes of Egypt, to be intelligible only to the initiated and learned, before the demotic or common letters were used.

I have recently seen the beautiful cross at Nevern, near to Newport, in Pembrokeshire, where the interlacings assimilate to those of the Leeds Cross, as it has been named; or it may possibly resemble more closely the interlacings of some of the six other crosses, fragments only of which were discovered, previous to my announcement in the Leeds Philosophical Hall, which occasioned their disappearance from the vestiges of the Old Parish Church.

These fragments were of various dimensions, and one of them had a Runic inscription, a portion of which was upon the only fragment discovered.

On carefully examining the margins of the panels or bands which separate them, there does not appear the least indication of their ever having had inscriptions upon them, not a letter or mark of any kind appearing under the most favourable light, which distinctly shews the curls of hair on the heads.

NOTICE OF THE SKULL OF A DOG EXHUMED FROM THE ALLUVIAL GRAVEL OF NORWICH, IN 1851. BY MR. H. DENNY, A.L.S.

From the difficulty which apparently exists in identifying the Fossil remains of particular species of animals, as for instance, those of the Genus Canis, I avail myself of this opportunity to bring before the Society a short notice of the skull of one of the Canidæ, which I believe to be that of a Dog, recently presented to the Museum of the Leeds Philosophical Society, by P. O'Callaghan, Esq., of Cookridge Hall. This specimen was exhumed from a bed of gravel at the depth of sixteen feet, along with the bones of Deer and other animals, in the year 1851, by some workmen employed in sinking a shaft for a new chimney at the gas works in the parish of St. Martins, at Palace, in the city of Norwich.

The first comparative anatomist of the day, Professor Owen, in his valuable Manual of *British Fossil Mammals*, appears to be of opinion that it is extremely difficult to distinguish, with certainty, the skull of the Dog from that of the Wolf, from the specimens which have come under his observation; and that the majority of those remains which have been assigned to the Dog, do not differ sufficiently from those of the Wolf to warrant their separation. There are, however, *characters* in the latter to which Professor Owen alludes, which I think are sufficient to identify the Wolf. These are the great size of the canine teeth, the greater length and height of the occipital sagittal crest, and the triangular space between the orbits being narrower and flatter, and there are others I have observed to which I shall shortly allude.

In the specimen to which I have to call your attention, the characters of the Wolf are not developed, and it consequently suggests the probability of its having belonged to a Dog. The absence of these characters does not arise from age, as the animal appears to have been mature. The sutures of the cranium are perfectly united, the teeth full formed, and if we may judge by comparison of the skull, the animal has been rather larger than the Greyhound of the present day; probably more resembling the ancient Irish Staghound, remains of which occur in the bogs in Ireland, and I believe in similar situations with those of the Wolf and Gigantic Deer.

When compared with the skull of a young Wolf of equal size, the difference in form is very perceptible. The greater length and narrowness of the intermaxillaries and nasal bones, the smaller size of the canine teeth, and the still smaller size of the molar teeth, the latter of which are at most only about one half the size of those of the young Wolf. Although our specimen, as I have already stated, has been a mature individual, which is an important point to bear in mind, as, supposing it to have belonged to a Wolf, these characters ought to have been just the reverse. The incisors, also, are much smaller in our specimen. In the young Wolf's head, I observe a greater breadth of the nasal cavity, one inch wider than in the Dog, and, consequently, more space for the turbinated bones, upon which are spread the olfactory nerves or organs of scent, a faculty peculiarly acute in the Wolf, but the reverse in Dogs of the Greyhound tribe, which chase more by sight. The orbital projections are more acute, the width across this portion of the head being greater by half an inch, and the occipital ridge more elevated than in the Wolf, with which I have compared it, but neither of these characters I consider of much value in the present instance, as the latter animal having been a young one, these parts are less developed at this age than they would have been in mature life, a point I regret that I have not had an opportunity of verifying, by examining skulls of the Dog and Wolf of similar size and age.

On comparing the two skulls from above, by far the most prominent character in the Wolf, is the greater breadth of the maxillary bones below the zygomatic arch. On viewing the under side, the larger size of the tympanic bones are also very striking, allowing greater capacity for the organs of hearing, another feature highly characteristic of the Wolf. As fossil bones are considerably heavier than those from recent animals, and lest any doubts might be entertained of its antiquity, I was desirous of testing this point, and the result was satisfactory. The skull of the recent Wolf weighed seven ounces, while that of the fossil Dog weighed ten ounces, which additional weight it would be unreasonable to suppose could be the effect of only a few years interment; and, therefore, I conceive that any supposition of its recent existence is untenable, and, also, that the skull has belonged to a Dog, and not to a Wolf, is, I think, equally apparent from the dissimilar characters I have pointed out.

Wishing for the opinion of my lamented and highly talented friend, the late Dr. Ball, M.R.I.A., of Trinity College, Dublin, I forwarded him a correct sketch of the skull in question, and received the following reply, which supports the supposition I have ventured to advance:—

3, Granby-row, Dublin, July 30th, 1856.

My Dear Sir,—The sketch you send is of the contour of a Wolf's head, of, perhaps, two years old; but, if the drawing be correct in the proportions of the teeth, the largest molars and the canines are not large enough for a Wolf. I would, therefore, say your specimen is the skull of a Dog, of a Wolfish aspect. I have studied the subject a good deal, and made instructive collections, and have Wolves' skulls of many ages as well as Dogs of various breeds, and several of both species from the bogs. I have not yet got any skull of a Dog so large as I should suppose our great Irish Dogs possessed; I rather imagine these animals were at all times rare, and, probably, the property of great men. If they at all exist at present, they are probably in the mountains of the north of Africa, where is to be found a Dog possessed of the proportions ascribed to our ancient animal; and knowing from other circumstances that some intercourse existed in remote ages between the north of Africa and Ireland, hence I am led to believe came the great Dog in question.

Truly yours,

R. BALL.

In conclusion, I would observe, it is not a little remarkable that of the animals which man has rendered subservient to his use, few remains occur in a fossil state. The Ox, Swine, Goat, and the Horse, are, I believe, the only examples; while those of the Dog and Sheep, which are and have been more immediately associated with his various migrations, are either unknown or doubtful. Can this arise from the supposed greater antiquity of the former animals, or that the latter are altered by domestication from other animals, as the Dog from the Wolf, or the Sheep from the Argali, or some other untamed species of Sheep? The former point is a geological problem which it is very difficult to solve, as the life periods of some of these animals is so interwoven with that of others of supposed remote date, and long since extinct. The latter is also an obscure page of past history, which, however, is not so beset with conflicting evidence. That the Dog, as a species, has existed from the earliest period of man's history is evident, as the monuments of Egypt and Nineveh testify, upon the ruins of which we see different varieties of this animal depicted or sculptured, as also from the various allusions in Scripture to its habits. In the earliest or Pantheistic age of Egypt, the Dog was deified; but in other nations it was allowed to prowl the streets unowned and uncared for, which would militate against any supposed change in its character from domestication in remote ages. The strongest argument, however, I conceive, (independent of anatomical peculiarities,) against the Dog being only an animal altered by circumstances, and originally descended from the Wolf or Hyæna, is the fact, that all these animals are separately and accurately, as regards their habits, described in the Sacred Writings; and, consequently, were at that early period in the world's history as distinct and well known as at present.

It is also worthy of remark, that in every part of the globe where man exists, the Dog is his associate, and in some instances even more docile than his master, as we find is the case in the species, or variety inhabiting New Holland, where the natives are the most brutal of the human family. The Dog, therefore, having existed as a species as early, if not anteriorly to the human era, there does not appear any plausible reason why its remains should not occur in the superficial deposits, as well as those of its contemporaries the Hyæna and Wolf, which are distinctly identified and allowed to be fossil, especially when the latter is known to have inhabited this country as late as the 17th century. With regard to the Sheep, however, the evidence is not so conclusive, but that it has been derived from some other allied species is more than probable, from the fact, that in no country in the known world does the Sheep exist wild with its present characters. That the period of its domestication is, however, very remote, is evident from the circumstance that the pastoral occupation of the progenitors of our race forms the theme of both sacred and profane historians in the earliest ages of the world; and it is a significant fact, as Professor Owen remarks "that the Scythians of the elevated plains of Asia Minor, who, according to Herodotus, obtained felt; and according to Strabo, food from their flocks, as well as the patriarchal Hebrew shepherds of the plains of Mesopotamia; the earliest instances of pastoral life, dwelt in that part of the earth where the wild Argali (*Ovis ammon*) still exist in greatest numbers." Why, however, remains of this animal have never been exhumed is a most extraordinary circumstance, as it is certain that the Sheep has been a contemporary of the Ox, Horse, Deer, Swine, and Goat, which have alike continued down to modern times both wild and domesticated, and would be subject like them to the same geological catastrophes, and consequently ought by parity of reasoning to be found under similar circumstances.

Only two suppositions can be hazarded to account for the absence of the bones of the Genus Ovis, and neither of them are satisfactory. First, that anteriorly to the human era, they became the prey of the various carnivorous animals which then predominated, and which, like the Hyæna, might even devour their bones, and thus obliterate all traces of their former existence. That such a fate befel the other Ruminantia is evident; but yet in the caverns and beds of alluvium fragments of such bones occur with those of their carnivorous destroyers. Secondly, If we suppose that the Sheep did not exist previously to the human era, and were indigenous only in the east, with the geology of which we are not so familiar as with the various countries of Europe, there is still a remote probability of their bones being exhumed; unless it is argued that all the deposits in which they could occur, date from an epoch long anterior, and that since its introduction into Europe no geological changes have taken place of sufficient magnitude to entomb any number of their bones. Lastly, the Sheep is an animal of such general consumption for domestic purposes, that none of its remains are scattered over the country to be drifted by local floods into caverns, or imbedded in alluvial deposits.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-SEVENTH MEETING, HELD IN THE COURT-HOUSE, BARNSLEY, ON THURSDAY, JULY 16TH, 1857, AT TWELVE O'CLOCK AT NOON.

Mr. DENNY having read letters from the Right Hon. the Earl Fitzwilliam, the President, and Lord Londesborough, one of the Vice-Presidents, regretting their inability to attend the Meeting, the Rev. RICHARD E. ROBERTS, M.A., Incumbent of St. George's, Barnsley, was called to the Chair.

The Rev. CHAIRMAN, having addressed the Society in a brief speech, called upon Mr. DENNY to read the first paper :—

ON SOME ANCIENT BARROWS, OR TUMULI, RECENTLY OPENED IN EAST YORKSHIRE. BY THOMAS WRIGHT, ESQ., M.A., F.S.A., &c. &c.

The town of Bridlington stretches from east to west along sloping ground which rises towards the north. The higher ground above the town is called Hunton, and commands towards the south an extensive prospect of Bridlington Bay and Holderness. This high ground is divided into fields, in one of which, occupied by Mr. William Brambles as tenant of the Corporation of Beverley, and in other fields adjoining, there is a continuous embankment, inclosing a long square, within which are remarked many pit-formed hollows in the ground, and boulders and other stones which appear to have been brought from the beach are turned up by the plough, especially near the embankment. According to the popular tradition of the locality, this place was at some remote period the site of a town or village; but such traditions are to be received with caution, and the number of large barrows scattered about would seem rather to point to the brow of the hill as a primeval cemetery. Its position is exactly such a one as the early inhabitants of our Island were accustomed to choose for that purpose.

Five of these barrows have been recently opened by a Yorkshire friend, Mr. Edward Tindall, of Bridlington, a gentleman who has made himself remarkable for the zeal and success with which he investigates the remains of antiquity in that district, and I have thought it would not be without interest to the members of the Society to give them a brief account of the result of his investigations, according to the information I have received from Mr. Tindall himself. Mr. Tindall commenced his labours (assisted by his friend Mr. Collinson) at the beginning of the month of April, 1857, and opened a tumulus standing by itself, and the nearest of them all to the town. At the depth of about two feet from the top of the tumulus, the remains of two skeletons were found, among burnt earth and a little charcoal. The bones were much decayed, but the jawbone of one of them, which was better preserved than the rest, was pronounced by a medical gentleman present, (Dr. Allison,) to be that of a youth under fourteen years of age. Mixed with the burnt earth and charcoal were several strippings of flints and a quantity of light-grey vegetable ashes. Mr. Tindall continued the excavation until he came down to the chalk, but found no other object of interest.

At a short distance from this tumulus are two others, near together, in a field belonging to Yarborough Lloyd, Esq. One of these was opened on the 10th of April, and presented some peculiarities of construction. The chalk rock had first been uncovered and hollowed out into the form of a bowl about eighteen inches deep, and nine feet in diameter, for the reception of the deposit. After the latter had been placed in it, the bowl was filled in with fine mould, and above this was raised the tumulus, formed of large chalk stones covered over when finished with a coating of rubble, and earthed up at the top with fine soil. This tumulus was about five feet high from the surface of the chalk. No traces of human remains were found in this tumulus, but there was a considerable quantity of bones of carniverous and ruminating animals, fowls, &c., and three articles in bronze, one of them a fibula of rather unusual form. This object will be best understood by the accompanying figures, (figs. 1 and 2,) representing it as seen in two positions :—

Fig. 1.

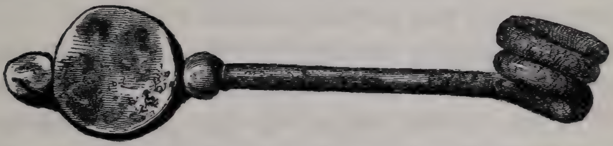

Fig. 2.

Figs. 1 and 2. A Roman Fibula.

The other two objects were also bronze fibulæ, in the shape of a plain ring, and exactly resembling each other, (fig. 3.)

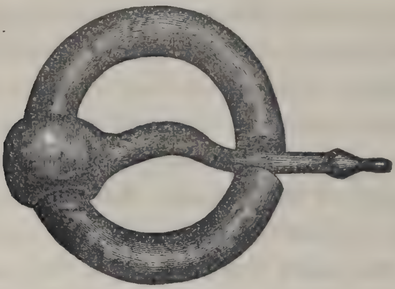

Fig. 3. Circular Roman Fibula.

These three articles are undoubtedly Roman, and I should think not of the earlier period of the occupation of our Island.

The other of these two barrows, which was next opened, closely resembled the former in its construction, though the hollow in the chalk was not quite so deep, but nothing further was found in it except a few fragments of bones, with charcoal, burnt earth, a small quantity of dark-coloured fatty earth, and four flint implements.

At the beginning of May, Mr. Tindall opened a fourth tumulus, in another field at some distance from the others, and on the highest ground in the lordship, which was attended with discoveries of a somewhat remarkable character. It was nearly forty yards in circumference, and as the shortest way of arriving at the probable place of deposit, the workmen were directed to sink a shaft from the top. In their passage down they found "a remarkable quantity of boulder or cobble stones, placed in the same manner as a grave is generally sodded up in a churchyard, and at each corner there were five stones placed in a horizontal line," and radiating as it were from a centre. At the ends of two of these lines of stones, which were opposite to each other and a yard deeper in the barrow, were found two urns of slightly baked earth, containing "a sort of brown paste or fat matter," with some pieces of leather and a quantity of hair, which Mr. Tindall compares to the hair of a cow. The urns, which were below, but not immediately under, the stones just alluded to, were placed in hollows in the chalk made for their reception. A flat piece of flag-stone was placed over one of the urns, and a similar piece of chalk over the other, and one of them stood nearly in its original upright position, while the other was crushed to pieces. There was here also a bowl-shaped hollow in the chalk, over which was a layer of ashes, charcoal, and burnt wood. Among this was found a piece of leather, some bits of iron which appeared to have been nails, and two pieces of flint chipped into the form of crescents. It is worthy of remark also, that some of the leather was cut and jagged at the edges in a manner that would lead us to believe that it had belonged to some ornamental part of the dress.

The fifth tumulus was opened on the 26th of May, by a trench cut through it from east to west, about five feet wide. About a foot beneath the surface occurred a layer of boulders, and under these, burnt bones and earth, and some much corroded nails. Mr. Tindall also found here a few cinders of *mineral coal*, about seven pieces of mineral coal unburnt, each about the size of a walnut, and one similar bit of kennel coal; and also, which was the most extraordinary of all, a piece of a tobacco pipe made of pipeclay. In the body of the tumulus were found the branches, remarkably well preserved, of what was believed to have been a blackthorn tree, and several decayed pieces of wood.

Tobacco pipes have been found before in very singular approximations with objects of remote antiquity, and they have even been supposed to belong to a period long antecedent to the introduction of tobacco into Europe, when some other plant is conjectured to have been used as a narcotic. My friend, Dr. Bruce, in his excellent work on the Roman Wall, has engraved two of these pipes, and mentioned others, found on Roman sites in the north of England. Another friend, well-known for his careful as well as learned antiquarian investigations, the Abbé Cochet, found both shanks and bowls of similar pipes in the Roman cemetery at Dieppe, in Normandy, and they have also been met with in a Roman Cemetery near Abbeville. They all seem to me to present by far too close a resemblance to the pipes in use about the time of James I. to be ascribed to any much earlier period, and we must, I think, ascribe these anomalous positions in which they are sometimes found to mere accident. We know how common a practice it was in former days to dig into these ancient tumuli in search of imaginary treasures, and it seems to me not impossible that some subject of our first king of the Stuart dynasty, engaged in a search of this kind, may have dropped his broken pipe in the Bridlington tumulus. With regard to the mineral coal and cinders, Mr. Tindall assures me that it was found at the bottom of the tumulus, among the original deposit; and although the circumstance is a very extraordinary one, it is not impossible or even very improbable. It has been fully ascertained that the Romans in this island used mineral coal. Extensive remains of their coal mining operations have been found in Northumberland, and I believe in North Wales, where the seams cropped out at the surface; and the cinders of mineral coal have been met with in more than one instance in the fire-places of Roman villas. I will mention as rather a curious coincidence with what was observed in these Yorkshire tumuli, that the Abbé Cochet found as the usual accompaniments of the urn interments in the Roman cemeteries he opened in Normandy, pieces of chipped flint, generally formed into the shape of wedges, which would of course hardly differ in shape from what we are accustomed to call flint axes. Of the two urns, of which Mr. Tindall has sent me drawings from which the accompanying cuts were made, one (Fig. 4) I consider to be Roman, that is, belonging to the Roman period; the other (fig. 5) belongs to those ruder forms which are common in the Yorkshire barrows, and which are generally called, without any positive reason, British.

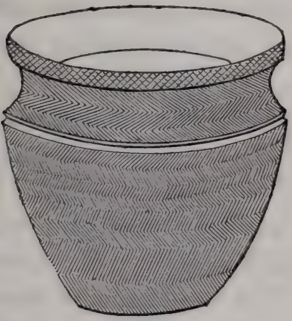

Fig. 4. Supposed Roman Urn.

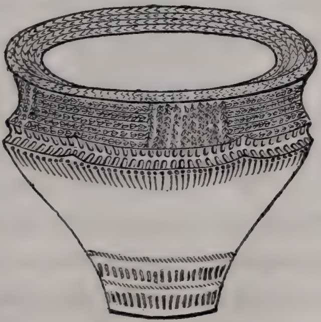

Fig. 5. Sepulchral Urn.

In this example, however, it appears to me that we may distinctly recognise debased copies of the ornaments of the Samian and other Roman ware, such as (in this example) the egg-and-tongue and the platted band ornaments, and it strengthens me rather in a suspicion that this class of Yorkshire tumuli will prove eventually to belong not to the British but to a very late Roman period. In spite, too, of the coarseness of the manufacture, the outline, when drawn correctly, as in my cut, is an evident imitation of Roman forms.

While speaking of urns found in this neighbourhood, I may mention two which came into the possession of Mr. Tindall that are especially deserving of notice. One, represented in the cut Fig. 6, is barrel-shaped, with peculiar ornamentation, and was filled with black earth, in which was found a large bead of jet. An urn of similar shape and character, and equally ornamented, is in the possession of Mr. Cape, of Bridlington. The other urn to which I allude, was extracted in Mr. Tindall's presence, from a barrow, in a field in his neighbourhood, when the earth was cleared away by the farmer, and was still more remarkable in character. Its surface was not only embellished with ornaments, but by a pictorial repre-

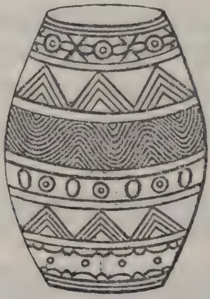

Fig. 6. Sepulchral Urn.

sentation of a warrior in a chariot drawn by two men, and preceded by two others carrying spears. Unfortunately, this curious urn was very dishonestly purloined from Mr. Tindall soon after it came into his possession, but he preserved a rough drawing of it, from which the accompanying cut (fig. 7) is reduced. I may add that the group here represented is repeated on the other side. It may be remarked that the swords in this group bear a close resemblance to one represented in a sculpture found at Birdoswald, (Ambogfanna), on the Roman Wall, which was intended to represent a soldier of the Dacian cohort established at that place.

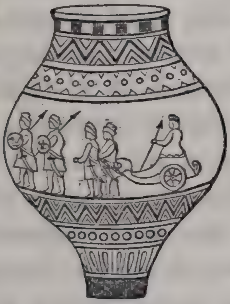

Fig. 7. Roman Urn.

It is to be hoped that Mr. Tindall will continue his exploration of the barrows in the neighbourhood of Bridlington, as I believe there are still several which remain unopened. I will merely call attention to one, at some distance to the north of that town, which has been partially excavated since the foregoing remarks were first laid before the society.

At the beginning of October last, I paid a visit to Lord Londesborough, who was then in his residence at Scarborough, and it had been arranged that we should take that opportunity of opening a very large barrow at some distance to the south of that town. This barrow, which is a mound of earth above sixty feet in height, and about 300 feet in circumference, is popularly known by the name of Willey-hou (*hou* being in that part of the country synonymous with barrow.) It stands on the slope of one of the lower chalk hills of the wolds, a few miles inward from the coast, at the distance of somewhat less than a mile from the village of Wold-Newton (which is rather to the northward of it), and about a mile and a half from that of North Burton (which lies nearly south.) At the foot of the bank, below Willey-hou, runs one of those curious intermitting streams common to the chalk districts, which is known by the name of *the Gypsies.*

On Monday, the 5th of October, a sufficient number of men were set to work in cutting a large trench from one side of the tumulus to the centre, but the time required for such an excavation had been much underrated, and up to the Thursday the only result was the clearing of a large portion of a level floor, at some elevation from the base of the tumulus, which was covered with a coating of wood ashes and other burnt materials. On the day just mentioned, our attention was carried away to another discovery, that of some interesting Anglo-Saxon interments near Scarborough, which proved for the moment the more attractive of the two.

This discovery had interrupted our plans with regard to the great tumulus of Willey-hou, and as it would have required another week or more to explore it properly, it was abandoned for the present. I have no doubt whatever that it is a sepulchral interment of the Roman period, but it may probably contain nothing but an urn filled with bones. This great tumulus is, however, especially interesting from its connection with the stories and legends of ancient times, which are as much characteristic of races as language itself, and travel with them or with their divisions in the same manner. The example I have to relate shows how durable such stories are in the minds of peoples. We sometimes find, in opening these tumuli, the traces of depredations committed upon them in former times in the belief, which prevailed generally, that vast treasures were concealed beneath them; but fortunately they were protected also by another article of the superstitious creed, the belief that these treasures were placed under the charge of fearful dragons, or of still more powerful fairies or demons, who were sure to take vengeance upon any one who attempted to rob them. The treasure-hunters, therefore, who went to work in earnest, sought the assistance of magical incantations, which were not always easily obtained. The tumulus of Willey-hou, which is one of the most celebrated in this part of England, was the subject of a legend of very remote date.

One of our most valuable historians of the twelfth century was born at Bridlington, in the first year of the reign of King Stephen, (A.D. 1136), and afterwards becoming a Canon of Newburgh, in the same county, is commonly known by the name of William of Newburgh. He seems to have been fond of the legends and popular antiquities of his native place, and he tells us that he had often remarked the tumulus to which the following legend belongs, which he has taken the trouble to hand down to us. There can be no doubt that it is the barrow of Willey-hou. He describes it as standing about half a mile from a village, of which he has omitted to tell us the name, but which was, no doubt, Wold-Newton; it was near "those celebrated waters, which are commonly called *Vipse*, and spring from the earth in a copious stream, not continually, but at intervals, after intervals of years." This stream was no doubt the *Gypsies* already mentioned.

One day, a rustic of the village just mentioned, went to visit one of his friends in a neighbouring village, (no doubt North Burton), the road to which lay near our tumulus, a road, therefore, which we may easily suppose people would not then willingly choose to pass at night. However, the love of beer, which was then even more powerful than at the present day, kept the rustic visiter until a late hour at night, and when at length he started on his way home he was at least all the happier for his entertainment. As he approached the tumulus, his astonishment was great to hear merry sounds issuing from it, which betokened that it was occupied by a party who were feasting and singing. Wondering who could have come to that lonely spot to enjoy themselves at such an hour, he approached nearer to the mound, and then, for the first time, he saw a door open in its side. Our rustic friend, who was well mounted, rode boldly up to this door, looked through it, and beheld, inside, a spacious apartment, brilliantly illuminated, and a large company of men and women seated at a magnificent entertainment. As he stood there staring at the door, one of the cup-bearers, seeing him, approached and offered him the cup to drink. Now it must be remarked that, according to the doctrines of fairy lore, (for these were fairies,) when a mere mortal approached their assemblies accidentally, the fairy-folk always offered him some of the liquor they were drinking, and if he drank it, he immediately lost all power of returning home, and was carried away into fairy-land. But the rustic of East Yorkshire was too wise for that, for he poured the contents on the ground, and, grasping firmly the cup, started off at full gallop. The fairy feasters rushed from the tumulus, and gave chase, but the horse of the fugitive was a good and swift one, and almost by miracle he reached his village in safety, and secured his valuable prize. He had, however, a chance in his favour which William of Newburgh has forgotten to state. It was a popular belief equally in the time of the fairies and in that of the witches, that if you once placed a running stream between yourself and your unearthly pursuers, they had no longer any power over you. At a very little distance from Willey-hou, the stream of the Gypsies must have protected the fugitive in his flight to Wold-Newton. His prize turned out to be a vase of unknown material, and equally strange in form and colour, *(vasculum materiæ incognitæ, coloris insoliti, et formæ inusitatæ.)* This extraordinary cup was soon talked about far and near, and at last it was given to King Henry I.—for it was in his reign that this event occurred. Henry subsequently presented it to his brother-in-law, King David of Scotland; and many years afterwards the second King Henry, visiting the Scottish court, was shown this wonderful cup, and begged it of William the Lion, who then occupied the Scottish throne. "This story," says William of Newburgh, "may appear strange, and people would not believe it if it had not been attested by the most trustworthy witnesses."

And, in fact, there may have been some truth in it; for it is not impossible that somebody digging into the tumulus may have found an urn which, from its rarity, may have been thought not unworthy to be presented to the King, and that the legend may have been added to give more interest to it. It is a common legend, and has been repeated under various forms and circumstances.

This legend, as we see, existed early in the twelfth century, or more than seven hundred years ago. I learnt, during my visit to the spot, that it still exists, though in a debased form. The peasantry now tell us that, one winter's night, a farmer returning from market heard, much to his astonishment, sounds of mirth and revelry proceed from Willey-hou, whereupon he rode up to the hill to ascertain the cause of this extraordinary occurrence. As he approached, a little dapper man presented himself with a cup of welcome. The farmer, supposing it to be silver, drank the contents, and setting spurs to his horse rode off with the treasure, but on his arrival at home to his great disappointment he found that it was nothing but base metal.

This is not the only legend which the peasantry of the neighbourhood have preserved relative to Willey-hou. They tell you gravely that years ago some avaricious personage dug into the tumulus in order to gain possession of the treasure it was supposed to contain. At length, after much labour, he came to an immense iron chest, the receptacle of the coveted riches, but the lid was no sooner uncovered, than it lifted itself up a little, and out sprang an immense black cat, which seated itself upon the chest, and glowered with eyes of fire upon the insolent intruders. Not daunted by this, after making various ineffectual attempts to move the chest, the digger for treasure fixed to it a strong chain or rope, to which he attached so numerous a team of horses, according to some accounts, or bullocks, according to others, that they reached two and two from the tumulus to North Burton, a distance of full a mile and a half. When all these preparations were completed, the director of these operations gave the order for moving exultingly in the following words—of course addressing his animals :—

Hep Joan ! prow Mark !
Whether God will or no,
We'll have this ark.

He had hardly uttered the words, when the rope and the traces broke in a hundred places, and the chest of treasure disappeared for ever.

There is a certain air of quaintness about the rhymes which seems to speak for the antiquity of this legend. The peasantry assure you further, that if any one run nine times round the tumulus without stopping, and then put his ear against it, he will distinctly hear the fairies dancing and singing in the interior. The old superstitious feeling relating to the spot seems, indeed, to exist almost as strong amongst the peasantry of the present day as it did ages ago; our proceedings excited general alarm among the lower classes, who expected to see some manifestation of vengeance on the part of the beings believed to hold the guard of the tumulus; and few would have ventured out in its neighbourhood after dark.

ON THE CRAG DEPOSIT AT BRIDLINGTON, AND THE MICROSCOPIC FOSSILS OCCURRING IN IT. BY H. C. SORBY, ESQ., F.R.S., F.G.S., OF SHEFFIELD.

When I was at Bridlington about seven years ago, examining amongst other things the crag deposit there, it occurred to me that probably Foraminiferæ might be found in it. Having suitable sieves with me, I washed some of it, and ascertained that they exist in considerable numbers. Since, so far as I am aware, no particular account of them has ever appeared, I purpose to give, now, a short description of the manner of their occurrence and how they may be obtained.

The place where the crag was then best exposed, was at the bottom of the cliff, somewhat north of the town. It appeared to me to be a number of small beds of sand and sandy clay amongst the boulder clay of the drift, which occurs both below and above the part with shells, also itself containing many erratic pebbles, like those in the drift. Though some few of the shells are found elsewhere, yet they are most numerous about a quarter of a mile north of the pier. The section there exhibited, at the bottom, bluish grey clay with pebbles of chalk and flint, as well as of other rocks transported from a distance, passing upwards into similar clay without pebbles. Above this was a very variable deposit of sandy beds and clay, similar to that below, as well as some that is brown and quite like the ordinary boulder clay of the district, except in containing shells. Over this were sand and clay, and occasionally pure decomposed chalk, and then a mass of boulder clay of the usual description.

The lower part of the section is much contorted, in the manner so common in the drift strata, as described in my paper on that subject, published in the Report of this Society for 1851, p. 220, and there attributed by me to the action of icebergs. It is also well worthy of remark that the same force which produced these contortions appears to have fractured some of the shells imbedded in the clay and displaced the fragments, which, nevertheless, may often be found within a short distance of each other. I have in my collection a number of specimens of Saxicava rugosa that show this fact to great advantage. Indeed, it seemed as though the exposed crag was only the upper portions of the contortions, and that the main bed was below the level of the beach, and might not have been exposed in the cliff if it had not been thus bent and raised up by lateral pressure.

Some of the beds of the crag, as well as of the boulder clay, contain a considerable amount of carbonate of lime, which may be seen with the microscope to be due to the presence of decomposed chalk, the minute granules of it being often most easily recognisable by their peculiar form.

If the clay in which the fossil shells occur be washed in a fine sieve, the sandy material obtained contains many Foraminiferæ and Entomostraca, that may easily be picked out with a small wet camel's hair brush. By washing and sieving the sandy bed, and then, when dry, shaking it, the small shells, being lighter, rise to the surface, and I found in it some differing from those that I met with in the washed clay. Above a dozen species thus procured, which vary in size from one-tenth to one-fiftieth of an inch, have been carefully examined by my friend, Mr. T. Rupert Jones, so well known for his researches in that branch of palæontology. The various Foraminiferæ were inserted in the last edition of Professor Morris' Catalogue of British Fossils, and the Entomostraca have been described and figured in Mr. Jones' Monograph, published by the Palæontographical Society for 1856. According to him the species are as follows:—

Dentalina communis.
Lagena striata.
Polymorphina lactea.
Quinqueloculina seminulum.
Robulina calcar?
Truncatulina tuberculata.

and undetermined species of

Biloculina.
Guttulina.
Nonionina.
Triloculina.

Of these by far the most common is one of the species of Nonionina. The Biloculina, Triloculina, Quinqueloculina, Polymorphina, and Guttulina are not so numerous, but still moderately abundant, whilst the rest are more rare, and especially the Lagena, of which I obtained only two specimens from the sand, not having found any in the sieved clay.

All the determined species above named are found elsewhere. The Lagena, Polymorphina, Quinqueloculina, Robulina, and Truncatulina occur in a living state in British or European seas; and the Dentalina, Quinqueloculina and Truncatulina in the coral crag of Sutton, as made known by the researches of Mr. Searles V. Wood.

As already mentioned, there occur in the washed clay many shells of Entomostraca. These belong to two species named by Jones, (Palæontographical Society, Monograph on

Tertiary Entomostraca, p.p. 29 and 44, pl. iv., figs. 6 and 7,) Cytheridea Sorbyana and Cytherea concinna, neither of which have hitherto been met with anywhere else, either living or fossil.

ON COLLIERY VENTILATION. BY RICHARD CARTER, ESQ., C.E., OF LONG CARR, BARNSLEY.

In assenting to bring before the West Riding Geological and Polytechnic Society the subject of Colliery Explosions in connection with the sad occurrence at Lund-hill, in this neighbourhood, on the 19th February last, I cannot but feel deeply the important bearings of the question, and its peculiar claim to be brought before this Society—whose province it is to promote or encourage any means by which mining operations may be harmonised with the advancing steps of progressive science; to dissipate the miasma of uneducated prejudice, and to present the standard of practical wisdom and truth.

I have ventured to put forth my humble ability, well knowing that if I only elicit the interchange of a moderate amount of sentiment, on the part of those members of the Society whose practical acquaintance with the subject so eminently qualifies them for its discussion, and so discharge the battery of thoughtful speculation and reflection which the Lund-hill calamity has been the means of most naturally creating, I shall have done some service to the cause of humanity, as well as of practical science as applied to mining operations; and so have acquired ample reward for, and justification of, the step which I have reluctantly taken in appearing before you to-day.

It is not surprising that a catastrophe by which nearly 200 of our fellow mortals were instantaneously swept out of life into the stillness of death, should have induced the expression of various opinions and the propounding of various schemes of improvement through the ordinary channels by which public attention can be attracted. Some perhaps sound, whilst others have possessed a visionary and impracticable quality only.

It would be difficult to over-estimate the national importance of the mining interests of this country, and particularly that department of mining enterprise which allies itself to the discovery and winning of coal; and the rapidity with which the coal trade is being developed, to meet the growing requirements of our own, as well as of other countries, to which the commodity is exported, originates a duty which I fear is but too wofully neglected, of adapting all the appliances of colliery working to the altered circumstances,—which greater vigour imparted to the trade, and more extended demand on our natural resources, of necessity gives rise to.

Half a century ago, colliery workings were carried on at comparatively shallow depths; and we now find that most of our large establishments, such as Low Moor, Bowling, and Elsecar, have been planted in localities where valuable mineral seams have come to the surface, or laid at a moderate depth only below it. For a long period of their earlier history the operations of acquiring supplies of coal were, therefore, carried on with far less risk and difficulty than were ultimately to be contended against. Besides which, the force of competition, which now strains the last efforts of economy, had not then been felt, as urging on to the recovery of every particle of coal, from any given area, with the least possible expenditure of capital and labour. Time, in its onward flight, has added to the steady and ceaseless demands of the age—one after another have been taken the great strides of mechanical progress—and the century which has now passed has witnessed the steam-engine, cradled in tiny infancy, matured, and at length diversified, till nearly every department of human labour, animal toil, and marine transit, has been revolutionised by its sublime and stately growth. One achievement of its noble powers has succeeded another till the toils of animals, and of man, have been reduced comparatively to a pastime and sport. Alike insensible to the severity of winter and the relaxing heats of summer, our iron-horse enables us to glide through space; and with rapidity and ease, all but miraculous when contrasted with the facilities of intercourse known to our grandsires, we traverse the very length or breadth of our sea-girt isle, until at last even Neptune himself shall bow to the sceptre of our triumphant power, and a few weeks shall suffice to witness the launch of a vessel whose proportions and strength will enable her to tread his aqueous domain, bidding defiance to his storms, and securing digestive tranquillity and repose to the pilgrims whom, hitherto, it has been his delight to torture and afflict.

But if such be the transition which so short a period has witnessed, does it not reflect the labour and activity by which such an altered state of things has been brought about and maintained. And what class amongst the entire community can be said, now, to bear the severest remnant of bygone miseries and toil? Surely the poor collier, who, in his grim pursuit, raises the fuel and food of our Leviathan machine, should be at once the object of our attention and solicitude. The hardy ploughman, in light of day and sweetness of refreshing breeze, cultivated and produced the food for former agents, by whose power the means of transit, and excursive jaunt, were maintained. But the food we now require is had by toil, where even light is, at its best, but darkness visible,—and where the salubrity of nature's grand element of respiration and of life may be unconsciously and instantaneously rendered the medium of horror and of death.

It would appear from the statistics of our last census, that of the population of Great Britain, about 220,000 of our fellow-countrymen are now pursuing the occupation of coal miners. And from the vast stimulus given to the trade, as well as from the progressive exhaustion of the shallow seams of coal, in every part of the country, an increasing risk is gradually accruing to this vast and industrious body of men, which claims for its amelioration the best efforts of intelligence and science.

It is not intended to deny, or even to overlook, the numerous and powerfully directed efforts both of Government and scientific bodies, and individuals, to diminish, if not altogether obviate, the hazardous conditions under which the occupations of our mining population are followed out; on the contrary, I do not think that much would remain for the severer deductions of abstract science, if the full benefit were derived from what has been already done and published, for revealing the real nature and character of the difficulties to be encountered, and the most probable means of surmounting them. The researches of Faraday, Playfair, Graham, De la Beche, and Phillips, not to mention the names of many practical mining engineers who have laboured so nobly in the field, afford an abundant guarantee for this assertion. But the grand object to be attained is the application, in individual examples, of a sound principle of working in harmony with the knowledge we now possess, both of the agents which surround us with their mischief, and of the laws which those agents acknowledge, in order to their being placed more effectually within our control and command.

It would be presumptuous in a paper of this kind to attempt the definition of any plan or system of working, which should be supposed equal to the test of special and individual application. To a considerable extent every colliery requires a system of management adapted to the peculiar circumstances which its own position and winning may disclose. But there are general principles which have reference to all collieries, and which must in some degree enter into their individual management, in order to their safe and economical progress. And it is to these principles, as coming most directly under the province of the West Riding Geological and Polytechnic Society, that the observations of this paper are addressed.

If the subject were not one requiring the most diligent application of intelligent and educated skill, the duties of the mining engineer would be divested of much of their present importance; and little might be said in reproach of the systems (or, perhaps, more consistently speaking, of the want of system), which we find to exist. But it needs no argument to demonstrate the requirement of much practical wisdom and ingenuity, to cope successfully with the numerous difficulties which surround the operations of an active colliery; and so to conduct its working, as that under all the various circumstances which attend the miner, he may not jeopardise his own, or the safety of his fellow-workmen. For it too frequently happens that all are dependent on the risks which attend upon the conduct and operation of each individual workman in the mine.

The duties of the mining engineer, or practical manager of a colliery, seem then to comprehend scientific qualifications of a two-fold character; and which, for the sake of clearer definition, we may express as being mechanical and meteorological.

Into the former, or mechanical department, as related to the physical operation of getting and drawing the coal, it is not our purpose here to enter,—but rather to dwell upon the latter division of the subject, which bears more directly on the ventilation of the mine and the personal safety of those who labour in it.

The task of ventilation, if it had reference only to the supply of fresh air to the workpeople engaged in the mine, would become one of the simplest character, and would scarcely continue to be one beyond the reach of the most ordinary capacity to deal with it.

Besides contributing the vital element of respiration to the workmen, however, ventilation also embraces the removal of gases given out by the coal, and other strata exposed in the mine, and which, if not removed, are by their presence and accumulation ever surrounding the entire operations with danger and death.

Of the general character of the most important gas exuded from coal strata, known familiarly as fire-damp, or the carburetted hydrogen of chemistry, but little need be said. Its specific gravity, slightly more than half the weight of atmospheric air, renders it under certain conditions, peculiarly easy of removal by ventilation, although under other conditions, and those perhaps most commonly found in practice, this quality of lightness increases the difficulty with which it is expelled from the mine. Nature, however, in which we trace such inexhaustible evidences of Providential arrangement and design, has given another peculiarity to this gas, as if to stimulate the ingenuity of man, in providing for its effectual escape from the place where its presence might originate such fearful disaster and distress. It has neither colour nor smell, and hence may exist in the most dangerous proximity, without attracting the notice of the workman by whose light it may be instantly ignited, carrying ruin and death by its explosion, to every part of the mine. Surely we recognise in these peculiarities, admonitions, as of Providence, warning us of the kind of arrangements we ought to provide, in order to the free and voluntary exit of an agent, whose habit would be to escape from our presence rather than linger to our peril, if the conditions were not opposed to its retreat, which almost universally ally themselves to the systems of winning coal, now practised in this country.

Released as this gas is, by the continual getting and breaking down of the coal, and by the exposure of innumerable fissures and openings, through which it discharges itself from the strata into the mine, its natural and irresistible tendency is to lodge in the most elevated cavities which can be found for its reception,—and hence a powerful opposition is exerted by its own specific gravity to any channel of escape, which does not present the features of an ascending plane. And here we meet the grand parent of all our difficulties, and perhaps of all our woes. For the system of laying out collieries, now most commonly acted upon, by placing the down-cast and up-cast shafts in near proximity to each other, gives, after the works have been a short time in operation, a descending rather than an ascending way of escape, which the explosive gas or fire-damp is made to pursue (so far as its escape is effected at all), by being united in the air supplied from the surface for the respiratory and ventilating requirements of the miners, and of the Limbo of their arduous toil.

Beyond that which escapes along the return-air-courses, there is necessarily in every mine a considerable generation of gas, which exudes at places where no admixture with the return-air can take place; and this gas, with portions which escape admixture, even in the air-courses themselves, goes to furnish the supply, which, lodging in the "goafs" or places from which the coal has been exhausted, and in other parts of the mine, creates and perpetuates a magazine of explosive element, almost too fearful to contemplate.

It is not intended here to allege that a state of things, of which this statement affords a picture, obtains in all collieries, even of this district; or that abstraction of explosive gases, or fire-damp is impossible, or may not be effected, both from the "goafs" and other parts of the mine, along descending courses. But as a general rule it seems obvious that ascending modes of exit have advantages of the first consequence, not only in favouring the natural tendency of the element to be dealt with, but by ejecting it from shafts in advance of the workings, and upon the "rise" of the coal, all possibility of lodgment is removed, and the chances of explosion materially lessened, by the gases being carried off without returning through the active parts of the mine, and under circumstances which may be suddenly affected by changes of weather, variations of the barometer, and other conditions, which it is less difficult to conceive than enumerate.

The doctrine of advance shafts for ventilation is not presumed to be at all a novelty, and it is not set forward here except for the purpose of asserting its soundness in theory; and moreover, of expressing a strong belief, that much greater advantage might, and ought to be taken of this principle, in every system of colliery ventilation; although there may be cases where the time and expense to be incurred in the uniting, by underground drifts, of two shafts at opposite ends of the territory, would swamp the pecuniary prospects of success which a particular enterprise might indicate.

Having regard to the future, and when the workings are to be pressed along the dip of the coal, as also in the opening up of deeper and underlying seams, it is clear that very important advantages might be taken of existing shafts and workings, in forming air passages on the rise or ascending principle for use of our own, as well as of generations yet to come.

This proposition assumes for its practical application and value, an immediate survey by competent parties, of entire districts of coal, in order that provision should be at once made by giving greater permanency to some of the shafts now and hereafter to be sunk, as well as in securing the driftways intended to be left open, by an adequate amount of pillar coal to be left for their support and continuance.

So long as the system prevails, of ejecting the gases with the return air, and portions of "goaf" are allowed to receive the gas as a means of getting rid of it, the recurrence of fatal calamities, sweeping off the poor miners by scores and hundreds, may be regarded as events of but too sad probability; and although under any circumstances the transition from one principle of working to another, of a totally different kind, could not be effected save at a considerable expense of time and pecuniary resource, the obligation is not less binding if the lives and health of our mining population are thereby promoted and secured.

In the resolution of the present systems of working collieries, two primary objects may be admitted as governing the proceedings of those who have charge of their development: ECONOMY, as related to the price per ton at which the coal can be landed on the surface; and SAFETY, in the means to be employed for its acquisition.

These two objects press with equal claims for constant, unwearying, and devoted attention. But what is the answer which truth would dictate to the solemn inquiry—Are these claims equally respected?

However favourable the reply with respect to the original design, Safety in practice cannot be maintained. A thousand motives combine (and a vast proportion of them, perhaps, beyond the reach of human foresight to control and prevent) to jeopardise the question of Safety; and hence the fearful amount of fatality which attends upon the mining operations of the country.

How is this proposition affected, if we glance retrospectively at the practice of coal mining, and the steps by which we have attained to the methods now pursued? In early days, as we have already remarked, this mineral was obtained only at very shallow depths; and chiefly from winnings commenced at the outcrops of the seams, where attention had been arrested, of people who appear to have known but little of the grand doctrines of modern geology.

Their humble wants, as the measure of their operations, abundantly justified the neglect, on their part, of any elaborate systems of ventilation, even if the proximity to the surface had not exonerated them from the troublesome gases which endanger the operations of their ultimate successors.

But, passing from these early adventurers, what do we next become acquainted with? A bolder system of penetrating the seams, by means of shafts, and traversing the mineral stratum to greater or less distances, as occasion seemed to justify. This continued till, by degrees, the necessities of ventilation had ended in something like the scheme of Intake, Distribution, and Upcast, which we find in very general operation at the present day. How was our friend Economy behaving all the while? Did he invite poor Safety to his counsels, and with the vastly altered circumstances suggest a remodelling of the plan of operation? No, he even grudged the expense of an additional shaft, as an Upcast for the special purposes of ventilation, and actually made "a shift" for the emergency, by tubbing (or to use perhaps a more polite expression) "bretticing-off" a portion of the existing one, and thus performing all the operations of drawing the coal,—taking-in air for ventilating the works, and discharging the air after doing so, within the area of one small aperture or shaft, which in all probability was in its dimensions scarcely adequate for any one of the purposes, separately, which we have just specified.

Science beheld in sorrow the events as they occurred. But what wonder that she should fail to descend into the workings when she witnessed what was done on the surface!

A third era has dawned upon us; and, notwithstanding the stupendous growth of the trade, the immense increase in the population employed in it, and must we not add of the dangers attendant on that employment! what is the transition-state by which we are now distinguished? Why "Economy," after numerous explosions, and a catalogue of miseries on which we will not dwell, although it is not human quite to forget them,—and after being "drawn up before his betters" in various ways and places, was made to surrender, and we have at length a SECOND shaft conceded, and, happy to relate, the two constructed with very respectably increased diameters and areas; so that with the aid of a good fire (or to use a polite expression again) the "cupola," we do manage, when all the doors are properly shut, and the other etcæteras in correct order, to get air, though in various degrees of freshness and salubrity, to all the working places of the mine.

In taking leave of this inquiry, we must again hint, whether, in attaining the position we now occupy, as regards the practical development and working of collieries in this country, Safety and Economy have each had their due share of attention?

In the review we have taken of its history, we see nothing in its pedigree or its perfections to entitle the present system to immunity from interference; and, therefore, I have ventured, although with a crudeness for which I must apologise, to suggest a plan which, if it can be acted upon, should render obsolete the very term return-air-courses, by substituting a method by which the ventilation should be always direct; and the currents of air having swept through the mine, should be discharged by shafts, always in advance, and on the rise or more elevated side of the working places in which the labour of men or of animals is being employed.

If this can be accomplished, we not only provide escape for the explosive gases in the manner which their natural characteristics seem so forcibly to indicate, but we obviate at once the most fruitful source of practical danger, by withdrawing them from the passages and cavities of the mine, where they now intermix or retreat, to the detriment and peril of every living creature in it. For however energetic the current may be, which is maintained in the cupola or up-cast shaft, upon the present system of ventilation by return-air-courses, the stimulus does but apply in the direction of the air-courses themselves; and in such direction the energy is equally participated in by perfection and defects. Leakages from the right channel, as well as the proper current itself, receive accession of strength by the vigour imparted to the up-cast draft. But remembering the kindred relation of gases to fluid bodies, as regards obedience to certain laws of motion, we must at once recognise the energy due to their relative gravities; and, herein, the repugnance with which a lighter medium is made obedient to the impulses given to a heavier one. Hence the perfect repose of fire-damp in the lateral cavities or "goafs" of a mine, whilst the current of atmospheric and heavier air is sweeping past along the air-courses, in the direction of the up-cast. In active motion, the two may be blended. But no natural affinity exists which would secure dilution of fire-damp by a voluntary admixture of this gas with the fresh or atmospheric air where no current existed. And thus may be accounted for the presence of fire-damp, forming an independent statum, even in the passages along which, but at a lower level, the air may be sweeping in a condition of perfect purity and safety.

The practical lesson to be learnt from these facts is,—that along the return-courses of the existing system, which from the very nature of things implies a descending plane of communication,—no voluntary action can be relied on for inducing the escape of carburetted hydrogen or explosive gas. The consequence of which is, that the lighter and explosive gas, ever isolating itself from surrounding media, stealthily creeps into every cavity, away from draft or disturbance, until, by the fact of its separation and increase, it forms a perfect magazine of destruction, whenever, by accident or otherwise, the smallest atom of flame is brought into contact with it.

It will be argued in support of the system as it now exists, that superior elevations attained in the up-cast shaft, and the vigour with which, by rarefaction, the air is caused to move in it, must have the desired effect, and equally answer all the purposes we are contending for, of extracting the explosive gases from the mine.

The shaft may be, and no doubt is, in the manner referred to, made to operate as a "head" in impelling the currents of ventilation along the passages, in which, but for some artificial stimulus, the motion of air would be very trivial indeed. But the influence of an up-cast shaft, approached by descending passages, and placed on the dip-side of the active workings of the colliery, must be maintained in opposition to, and independently of, the laws which explosive gases naturally and voluntarily obey. And hence the complicated system of trapping and splitting, and coursing and heating, for the purpose of carrying the air to all parts of the mine, where its presence is desired in the capacity of scavenger, to withdraw the agents of mischief by channels along which they have of themselves no disposition to retreat.

The insidious and ever active force with which the lighter and dangerous gases seek out and obtain possession of all the most elevated cavities of a mine, indicates in language which cannot be mistaken, the soundness in theory of any plan of ventilation which harmonises with this voluntary habit of their nature. We have already shown, and experience abundantly proves, that the systems of working now in operation are not so harmonised; but, on the contrary, are in a most active sense directly opposed to it. Let there be vent provided on the "rise," and the gases themselves supply the place of the cupola furnace. Their tendency being to escape at the highest, and as experience would generally dictate, the most remote part of the workings, the question of unventilated goafs will lose much of its perplexing uncertainty and alarm, and every other arrangement attendant on the work of ventilation would so be simplified and improved. It would be easy for the purpose of strengthening the evidence in favour of *direct* ventilation by means of up-cast at the uppermost "rise," to enter more largely into the difficulties and uncertainty which attend in practice upon the existing system, with its allied necessities of return-air-courses, trappings, and stops. How by friction, leakage, and unforeseen casualties which cannot be enumerated, the processes of ventilation may be retarded, and perhaps in some degree suspended, to the great peril of part if not of the whole mine. But a word or two on other aspects of the case must close this paper.

We remarked at the outset that observations of meteorology were also amongst the prominent duties of colliery management. All experience and authority seem to sanction the direct influence of temperature, pressure, and other conditions of the atmosphere upon the practical ventilation of a colliery from time to time. And yet how rarely do we find any adequate recognition of this important truth in their management and superintendence. Effective ventilation being in the strictest sense the vital principle on which everything depends, every circumstance which affects it should have the closest and most intelligent notice and respect. I have observed on several occasions of violent explosion in different parts of the country, that they were accompanied by some striking variations of atmospheric condition; and who can tell to what useful results it might lead if a careful register were kept at every colliery, and returns made to some one recognised authority whence all could draw for information in the study of the natural laws on which so much of our safety and welfare depends. The subject needs but little application on the part of those more immediately interested, to deduce a plan of operation at once simple and effective. Mining operations may not be identified with as much of scientific perfection as we could desire; but it would be unjust to the proprietors of the present time to suppose that they were averse to their improvement. The period has arrived when some bold step must be taken for arresting them, or the disasters of explosion will be fearfully multiplied.

It is for societies like the one I have the honour of addressing, to perform their part by drawing attention to the indices of scientific truth. And may we not hope that under their auspices a mighty effort will be at once made to ameliorate the condition and brighten the prospects which attend upon the mining industry of our country. Already an association has been heard of in this district of the coal viewers and mining engineers, which I trust will be speedily organised; and that, if not in actual union, at least a most cordial intercourse may be established between such an association and the West Riding Geological and Polytechnic Society. I know of no arrangement more likely to advance the practical knowledge which it is desirable to obtain and bring to bear upon this all-important question. And whilst we congratulate ourselves on one, let us not overlook the indications of improvement in another division of the mining community of our district.

The last few weeks have witnessed a most encouraging evidence of self-advancement amongst the working miners themselves; and whilst in their praiseworthy efforts we heartily wish them God speed, still substantial aid should be forthcoming for enabling them to raise the standard of practical education in their own ranks.

To the ignorance of the working miner may probably be traced many of the calamities which have awakened the sympathies of the public; and if to dissipate this ignorance, is at once to promote their physical as well as moral safety, surely no object more worthy can elicit the beneficence and support of every humane and sympathising heart.

ON THE MIXED USE OF DAVY LAMPS AND NAKED LIGHTS IN COAL MINES. BY E. W. BINNEY, ESQ., F.R.S., F.G.S.

The mixed use of Davy lamps and naked lights in coal mines is a subject well worthy of the attention of a body like the Yorkshire Geological and Polytechnic Society. By the term mixed use, it is not only intended to apply to Davy lamps and candles, but to include lamps with the gauze so secured as a workman may open it either with his fingers or the use of a knife, an old nail, or such like instrument.

It is not necessary here to deprecate the use of lamps as a substitute for thorough and efficient ventilation. The illustrious inventor of the lamp never intended that it should be so used, and no coal proprietor who at all considers his own property or values the lives of his workmen would ever think of so using it. The first point to be attended to in a mine that gives out light carburetted hydrogen gas is to remove it as soon as possible by good ventilation. When this has been done, the lamp should be employed as a precaution against any stoppage in the ventilation by falls of roof or derangement of air-courses, or by the sudden liberation of gas from the roof or other part of the mine.

Lamps are frequently used on the opening of a seam of coal, in driving fast places, and where pillars are being robbed or worked back, whilst naked lights are in use over the greater part of the mine. This is the dangerous admixture that it is desirable should be openly condemned. The most experienced miner or best scientific man shall not be able to guard against the sudden coming of so invisible, intangible, and subtle an enemy as light carburetted hydrogen gas; nay, in some instances, shall not be able to detect its presence by any of his senses unless he has a light present. People who do not understand the nature and properties of this gas often talk about the reckless conduct of poor ignorant miners as if the latter rushed into it, just as a lot of boys jump into a pool of water, for mere mischief. The smell of gas used for the purposes of artificial illumination gives clear evidence of its presence by a smell resembling that of garlic, but this is certainly not the case with some of the most explosive mixtures of light carburetted hydrogen gas, which can be scarcely detected by the smell, even by experienced miners who have worked for years in fiery mines. Nothing shows the indefinite ideas that the men have of this gas as the names they call it by, as sulphur, wild-fire, fire-damp, &c. To say nothing about common colliers, speaking for myself, I should be sorry to trust any experienced underlooker or fireman's mere senses as to the presence of gas. I certainly once did so, and very narrowly escaped being burnt for my credulity. It has been stated that every collier ought to be able to examine his own place before he commences his work. Would that he were so. So far as my knowledge extends, it will be a long time before he will possess such an amount of information as to gas. Another circumstance which shows how ignorant really clever practical men were of the nature of the enemy they have to deal with, was the fearful system of trying a place for gas by a naked candle, and as the flame tapered up cut it off with their hands. This, it is to be hoped, is not now in use. Although some men, doubtless, were very clever in escaping being burnt in their investigation, their skill must be considered as that of thoroughly reckless men, just as reckless as if they were in a building full of casks containing an immense heap of black powder, and a zig-zag train of the same reaching from the door to the heap, and they wanted to find out its nature. To do this, suppose that they fired the train with a match, and trusted to stamping it out with their feet, so as to prevent its communicating with the heap. This may seem a mad way of testing the nature of gunpowder, but it is not a whit more insane than trying a fiery coal mine with a lighted candle for fire-damp.

In my mind, ignorance of the origin and properties of fire-damp is the chief cause of the explosions in coal mines. This want of knowledge of the subtle enemy they have to deal with is common to both officers and men. The proverb that "knowledge is power" is nowhere more applicable than when applied to fire-damp in a coal mine, for no intelligent officer who knows much of it will be long in removing it as soon as it is generated, and also be instantly prepared for its appearance in the mine when it is known to exist, or even when there is a mere probability of its existence. The mixed use of Davy lamps and candles in a mine where fire-damp is known to be in any part of the workings or waste is, to say the least of it, both reckless and dangerous.

I am well aware that most of the coal proprietors of this district are anxious to do everything they can for the preservation of the lives of their men and the safety of their property, and that no expense is spared by them to carry into effect their objects; but they have to leave all to their manager, and he has to trust to his underlookers;—all these may be good practical miners, and yet know little or nothing of the nature of fire-damp, the great and subtle enemy with whom they have constantly to deal. As long as coal is so extensively worked in England as it now is, the mines will gradually become deeper and deeper, and consequently more subject to fire-damp. Inspectors may do good, as they unquestionably have done, in spurring on and sharpening the officers of mines, but the Government inspection of mines would be worse than useless if the responsibility as to the state of a mine were transferred from the owner and officers to the inspector. Coroner's inquests, through the agency of the press, may bring the particulars of explosions before the public and find verdicts of "Accidental death" or "Manslaughter," the latter of which are generally snuffed out when they come before the grand jury and judges at the assizes; but depend upon it that year by year the explosions in coal mines will go on gradually increasing as the mines go deeper and the workings become more extensive, unless you have a more highly educated, thoroughly intelligent, and well paid staff of officers, and a body of educated, steady, and disciplined miners.

A SKETCH OF BARNSLEY, ITS MINERAL AND MANUFACTURING PRODUCTS, AND NATURAL HISTORY. BY MR. THOMAS LISTER, OF BARNSLEY.

This paper, which is only intended as a sketch of Barnsley and the surrounding district, necessarily involves a glance at its natural and manufactured products, its trading capabilities, and the general progress which has marked their development and wide extension. How marvellous the change a century has witnessed, since William and John Wilson, members of the Society of Friends, commenced in so humble a way as to send linen yarn over the moors to be woven near Mottram. The first bleach works were situated at the Old Mill; the canal, which was cut subsequently, dividing the upper part in Honeywell Field, which was purchased by Joseph Beckett, from the lower part, long tenanted by John Naylor, and now by Robert Craik. The bleach works at Beaver Hall were established about a century ago; a large shop for weaving custom work was constructed there also. John Lupton, also a Friend, was many years the proprietor of this establishment; he opened the way for the Lister family to come and settle at Barnsley,—his nephews, Joseph Lister (my father) and James Lister came to him young men; the latter becoming ultimately one of the firm of Jackson, Ellis, and Lister, which, with the establishments of Beckett, Greenwood, Taylor, and Dearman, were the principal firms up to the commencement of the present century.

The population has increased at a proportionate rate, since Joseph Beckett, in 1772, improved upon the practice of his uncles, the Wilsons, whom he succeeded, and instead of sending the yarn over the moors to be woven, he induced some of the weavers of Cheshire and Lancashire to settle at Barnsley, establishing the first loom in an out-house belonging to the large building yet existing in Beckett's Square. The population of the town at that period did not exceed 2,000; in 1811 it had reached 5,000; in 1831, 10,330; in 1851, 14,916; and now it is estimated at 17,000. The former staple trade of the town, the wire-drawing business, gradually dwindled down, until now it is represented by one sole establishment. On the other hand, the linen business expanded from its first simple beginnings in checks, ducks, and other plain goods, till it embraced fabrics of finer and more complicate texture as diapers, drills, and damasks. An entirely new branch has opened out of late years—the fancy drill manufacture for lighter wear in Southern Europe and the tropics. In this branch are embarked the four great firms of T. Taylor and Sons, Harvey and Co., C. Tee and Son, and Jackson and Hodgetts. The powerful agency of steam has been called into requisition, and developed our manufacturing capabilities to a vast extent. Within the last twenty years the following firms have established large steam factories:—T. Taylor and Sons, by far the greatest, employing 500 hands; J. B. Pigott, at Shaw Mill; Richardson, Tee, and Rycroft, at Bore Spring; Carter Brothers, at Oak Mill; and that of William Taylor and Sons, at Redbrook. The number of bleach works are six:—William Taylor and Sons, (Richard Day's Executors), at Monk Bretton; Samuel Coward's Executors, at Swithen; Robert Craik, at Old Mill; Edward Parker, at Stairfoot; H. Jackson and Co., at Midland Bleach Works; and H. J. and J. Spencer, at Robroyd.

A most important element of our material prosperity are our mineral beds, consisting of 14 workable beds of coal, intermingled with clay and ironstone, rising from east to west by south, which regularly bring their rich treasures to the surface. The workings in the Barnsley nine-feet seam have increased six-fold since many in middle life can remember; there are now twenty-four working pits, and in the Silkstone five-feet seam there are upwards of twelve.

Three railway lines meet in the town to convey its people and their productions to all parts of the globe.

THE COAL BEDS OF THE BARNSLEY DISTRICT.—The coal beds of the Barnsley district rise from under the magnesian limestone hills, which, in a long narrow range from north to south by west, skirt their eastern side. These beds rise at various angles, averaging about one foot in twelve in a south westerly direction, in a series of bold undulations; forming a picturesque, fertile, and well-wooded district. The elevations assume greater boldness and magnitude, and consequent sterility, towards the west. The height of the limestone range at North Empsall being 240 feet; of the Ackworth Rock, near Brierly Manor, 430 feet; at Keresforth Hill, where the Barnsley bed crops out, 530 feet; of the height above Oxspring, near the out crop of the Whin Moor Bed, 766 feet; of Sheephouse Plantation, over the celebrated Green Moor stone formation, 836 feet; while the

Millstone Grit ranges beyond, where no further beds of coal are found, excepting a few poor worthless seams, rise to elevations of from 1,000 to 1,900 feet.

In passing, then, from the magnesian limestone to the Millstone Grit, we traverse over the various mineral beds of the district, as they successively rise one from beneath the other. We have in this sketch little more than an enumeration of their names and the number of the principal workings in each. In the first place the thin beds of Upton rise from under the limestone, then the workable beds of Nostel, Crofton, Shafton, and Cudworth.

The Wath Wood, wrought about Melton; the Wood Moor, worked near Chapelthorpe and at Smithies, averaging three feet in thickness; the Beamshaw Coal, about two feet eight inches; the Mapplewell or Kents Thick, in some places three feet, but varying in different localities, as several other beds do. Then comes the Barnsley Bed, the thickest by far of the series, averaging nine feet, and having from twenty to twenty-four busily working mines on various points of its extent. Then comes the Swallow Wood Coal, about three feet, worked on the Dodworth Road; next rise in succession a series of beds, not much worked in this part, called by various names in different localities, as the Lidgett Coal; the Joan Coal; the Flockton Coal, one bed of which is worked at Higham; then the Park Gate Coal, four feet, worked at Higham; Silkstone Fall; Silkstone Common, at Stainbro' Colliery, No. 1 shaft; at Wharncliffe and Silkstone Colliery, No. 1 shaft; the deeper shafts at both places working the celebrated Silkstone Coal. Next is the Silkstone four feet coal, then the Silkstone Main Bed, five feet, worked in about sixteen different mines in this neighbourhood. Below this is the Whin Moor bed, worked at Silkstone Common and Thurgoland, three feet in thickness.

THE BIRDS OF THE BARNSLEY DISTRICT.—The birds found in this locality will generally occur throughout the south-west part of Yorkshire, known, geologically, as the Yorkshire Coal Formation, extending in a series of well-wooded undulations, from the magnesian limestone range, at near 300 feet elevation, to the great back-bone range of Millstone Grit, at a height of 1,700 feet above the level of the sea. Barnsley is near the centre, at a height of 390 feet, while the heights immediately overlooking it are 550 feet in elevation, there being a regular increase of height in a western direction. The birds then, may be expected to typify the district, being equally removed from the level regions, beyond the limestone range, where birds of the marsh and sea mingle largely, and the sub-alpine regions where the moorland birds predominate. With great variety of situation—fruitful fields, valley streams, sedgy pools, patches of gorse and heath, fine parks, and abounding woodlands, we have a good variety of birds, and should have many more, and more thickly distributed, if half as much pains were taken in preserving, after the manner of Waterton, as in destroying rare birds. This question is worthy of being taken up by scientific men, since all true naturalists will admit that there is more satisfaction in studying living objects than dead representations; and the chief of slaughterers, Macgillivray, confesses that all zoological collectors destroy ten times more specimens than they require. Of the summer warblers, we have all the truly British species, except the Dartford Warbler and the Reed Warbler; the latter is stated by Neville Wood to occur in the adjoining county of Derby. The times of their arrival in the district specified, as recorded in these notes, may be generally depended upon, except those kinds that are thinly distributed, as the Nightingale, of whose delightful melody the public are defrauded by the bird-catchers, as bad in their way as the egg and skin collectors; the Wheater, the Stonechat, and the Lesser Whitethroat, the two latter species not having been observed this season.

As observers multiply, more correct results as to arrivals, departures, and relative number of species may be obtained. To assist some of the young naturalists rising round us, in overcoming difficulties which I have had to encounter alone, I have intermingled suggestions not always deemed needful to insert in books. My only aids were book descriptions, an attentive ear serving as a guide to the eye in tracing the whereabouts of some uncommon bird, assisted, where practicable, with a small telescope, a more rational companion for a naturalist than the murderous gun, as with the former we can admire and spare for others to do so too, but with the latter we destroy the object of our present pleasure, and in the case of rare birds, we help to cut off the hope of future gratification.

The list drawn out by me of the birds that have been noticed, or that are now occurring in this part of Yorkshire, is given in great part from personal observation of the birds in their natural state, (the best mode of observing them,) or from inspection of various collections, or information given by competent parties. Some of the rarer instances, particularly of the water birds, I record on the authority of C. Waterton, whose protection of all birds gives him superior opportunities of studying them than those of the exterminating naturalist. I also record many which are in the late Dr. Farrar's collection, taken chiefly in the south-west of Yorkshire, and from his able paper on the subject, communicated by his son. Out of Yarrell and Temminck's list of 181 land birds known to Britain, 110 have been recorded for this neighbourhood; of 161 water birds, 69 only have been ascertained—a large number considering the wanton extermination to which they are doomed. Another arrangement we may offer that will give the same approximation to the numbers recorded. Of summer visitants of the warbler family we number 14; of other summer visitants, 19; of winter visitants, 29; of resident birds or partial migrants, 102; and of occasional visitants or stragglers, 19.

A few of the rarer birds seen in the Barnsley district by various observers, from 1833 to the present time:—The Peregrine Falcon—Horsecar Wood, Redmires, Walton, some years ago; Hobby—occasionally seen now; Osprey—two in Stainbro' Park (now at the Hall,) one at Worsbro' Reservoir; Kite—Horsecar and Lunn Woods, now extinct; Common Buzzard—one at Cannon Hall, and one at Woolley Park; Rough-legged Buzzard—Cannon Hall; Honey Buzzard—Wharncliffe 1840, Chevet Park 1857; Hen Harrier—Walton, nearly extinct; Little Owl—Wharncliffe; Chough—near Sheffield; Great Grey Shrike—Keresforth, Ethersley Wood, and Dearneside; Red-backed Shrike—Cliff Wood; Pied Flycatcher—Stainbro' Park, each summer, Wharncliffe; Wood Lark—Stainbro' Park, extinct in this district; Bearded Tit—Walton, and near Sheffield; Bohemian Waxwing—Cannon Hall and Carr Green; Common Crossbill—Silkstone Fall Woods, Hoyland, &c.; Hawfinch—Cannon Hall; Twite; Siskin—Dearnside, &c.; Barred Woodpecker—Wentworth Park; Wryneck—Worsbro', Silkstone, &c.; Hoopoe—Wombwell Wood 1847, Ecclesfield 1841, Norwood, &c.; Night Jar—various places; Turtle Dove—Walton and Badsworth; Black Grouse—Bradhill Moors; Oyster Catcher—Worsbro', Stainbro', &c.; Dotterell—one at Staincross; Ringed Plover—Fleets, Spring 1857; Little Egret—New Hall; Common Bittern—Bolton-on-Dearne 1845, Badsworth 1855; White Stork—Bretton Park; Common Curlew and Whimbrel—various places; Black-tailed Godwit—Haw Park; Great Snipe—Dearneside, Old Mill 1857, near Doncaster; Spotted Crake—one near Barnsley; Grey Phalarope—Old Mill, &c.; Sclavonian Grebe—Ecclesfield; Lesser Tern—Worsbro'; Black-backed Gull and Black-headed Gull—near Barnsley and New Miller Dam; Canada Goose—Walton; Sheldrake, Gadwall, Pintail Duck—Dearne Valley; Shoveller and Common Scoter—Worsbro'; Tufted Duck, Scaup Duck, Golden Eye, Pochard, Goosander, Smew, and Shag—Walton and various watery places; Great Northern Diver—Cannon Hall; Red-throated Diver—Woolley Park, Banks Hall, and Staincross; Little Auk—caught alive near Barnsley, November, 1853; Puffin—Dearne Valley; Stormy Petrel—caught alive near Barnsley, 1847.

In connection with this Paper, W. T. Smith, Esq., F.R.B.S., Edinburgh, of Barnsley, read a Sketch of the Botany of the district, drawn up by himself and H. Payne, Esq., M.D., from which it appeared that 492 Flowering Plants and Ferns are found in the neighbourhood, which, arranged under their natural orders, would present the following proportions:—

Ranunculaceæ...	19	Linaceæ	2	Caprifoliaceæ ...	3
Berberidaceæ ...	1	Oxalidaceæ	1	Rubiaceæ	8
Nymphæaceæ ...	1	Leguminosæ ...	32	Valerianaceæ ...	4
Papaveraceæ ...	4	Rosaceæ	30	Dipsaceæ	2
Fumariaceæ......	4	Onagraceæ	5	Compositæ	54
Cruciferæ	20	Cucurbitaceæ ...	1	Campanulaceæ . .	3
Resedaceæ	1	Paronychiaceæ . .	1	Ericaceæ	6
Violaceæ	3	Portulaceæ	2	Aquifoliaceæ ...	1
Polygalaceæ......	1	Crassulaceæ......	4	Oleaceæ	2
Caryophyllaceæ .	17	Grossulariaceæ. .	2	Apocynaceæ ...	1
Malvaceæ.........	3	Saxifragaceæ ...	3	Gentianaceæ ...	2
Hypericaceæ ...	5	Umbelliferæ ...	18	Convolvulaceæ . .	5
Tiliaceæ	1	Araliaceæ.........	2	Primulaceæ	5
Aceraceæ	2	Cornaceæ	1	Plantaginaceæ ...	3
Geraniaceæ	7	Loranthaceæ ...	1	Chenopodiaceæ. .	2

Polygonaceæ	14
Boraginaceæ	6
Solanaceæ	3
Orobanchaceæ	1
Scrophulariaceæ	18
Labiatæ	23
Verbenaceæ	1
Euphorbiaceæ	6
Urticaceæ	3
Ulmaceæ	2
Amentiferæ	19
Conifereæ	2
Trilliaceæ	1
Diascoreaceæ	1
Hydrocharidaceæ	1
Orchidaceæ	8
Iridaceæ	1
Liliaceæ	4
Juncaceæ	9
Alismaceæ	4
Typhaceæ	2
Araceæ	1
Lemnaceæ	2
Fluviales	7
Potomogetonaceæ	7
Cyperaceæ	20
Gramineæ	52
Equisetaceæ	5
Filices	12
Characeæ	1

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-EIGHTH MEETING, HELD IN THE
GYMNASIUM HALL, HUDDERSFIELD, ON THURSDAY, NOV. 5TH, 1857.

Rev. T. B. BENSTEAD, A.M., Incumbent of Lockwood, in the Chair.

The following gentlemen were elected Members of the Society:—

His Grace the ARCHBISHOP OF YORK.
EDWARD BAINES, Esq., Leeds.
THOMAS FIRTH, Esq., Toothill, Huddersfield.
JOSEPH SHEARD, Esq., Brooklyed, Mirfield.
JOSEPH HIRST, Esq., Wilshaw, Meltham, Huddersfield.
NICHOLAS CARTER, Esq., Huddersfield.
CHARLES STOCKWELL, Esq., Grange Moor, Huddersfield.
T. P. CROSLAND, Esq., J.P., Gledholt, Huddersfield.
JOSEPH FIRTH, Esq., J.P., Carr Hill, Huddersfield.
G. S. TOLSON, Esq., Dalton, Huddersfield.
WILLIAM COCKING, Esq., Architect, New Street, Huddersfield.
JAMES RADCLIFFE, Esq., Architect, Westgate, Huddersfield.
EDWARD WATERHOUSE, Esq., Lindley, Huddersfield.
Mr. DAVID SWALLOW, Gas Works, Bradford.
Rev. W. T. M. SYLVESTER, Castleford Rectory.
EDWARD BROOKE, Jun., Esq., Fieldhouse Clay Works, Huddersfield.
EDWARD FILLITER, Esq., C.E., Borough Surveyor, Leeds.
ANTHONY KNOWLES KAYE, Esq., Mold Green, Huddersfield.

Mr. W. S. Ward, the Secretary, read the first paper:—

ON AN IMPROVEMENT IN PRESSURE GAUGES. BY W. H. BARTHOLOMEW, ESQ., C.E., RESIDENT ENGINEER, AIRE AND CALDER NAVIGATION.

The writer's attention has for some time been directed to devising some means of increasing the employer's control over his engine driver, and it has led him to the improvement which he hereafter proposes to describe.

In laying this subject before you, it may be desirable here to state that he conceives it, and proposes to treat it, as more particularly applying to the employment of high pressure steam, and to engines of this class, perhaps, more especially the locomotive and steam boats, he selects as examples, because they are, when at work, so little under the eye of the employer.

It is a well known fact amongst individuals conversant with the working of the class of engine mentioned, that it is too frequent a practice (and perhaps a great temptation if not controlled,) for engine drivers—in the locomotive for instance, when behind time, or when ascending heavy gradients over loaded; and, in the case of steam boats, when contending against head winds, or running in competition with other boats—to screw down the safety valves much beyond the limited pressure, thereby in all probability endangering the boiler under his charge, or to say the least, injuring it in a greater or lesser degree, without leaving any immediate trace behind to convict him of his recklessness. To obviate this, the writer proposed to the Patentee of a very recent Pressure Gauge to add to the ordinary working index or pointer of the dial another index, which, for better comprehension, may be termed a Station Register Index; *this* Index, which is placed entirely out of the control of the engineer, is moved forward by the Working Index, and is left, or remains fixed at the maximum pressure attained by the movable Index, that is to say, it advances but does not recede with the movable Index, and is always at liberty to advance as the pressure increases beyond that of its (the Station Register's) last resting place; thus, to use a homely phrase, furnishing a very efficient "tell tale" to the employer, who is able at any time, by removing the glass face in front of the dial, (which, it is to be observed, is furnished with lock and key,) to place it back in any required position, thereby enabling him to institute a thorough check upon his engine driver in this respect.

The use of this simple expedient, the writer is persuaded, will be found of great practical utility, and he strongly recommends its introduction to all Pressure Gauges; and he begs to observe to the Society, the expediency of noticing to Government the desirability of enforcing its employment (or some other equally efficient means) for controlling the pressure of steam used, as it will be evident from the preceding that such an expedient would act as a very safe and reliable check upon the parties in charge, and would thus deter them from tampering with the pressure of steam; it would also, in most cases of explosion, define the cause, thus removing doubts to a considerable extent, as well as mere speculative theory. The following two objections may probably be adduced:—

1st. It may be advanced that the safety valves are removed out of the control of the engine driver if ferrules are placed upon the screws of the balances between the same and the levers, and, consequently, no further check would be necessary. In answer, it may be observed that such an expedient would only partially remove the control of the pressure from the driver; it, no doubt, would securely prevent him from screwing his valves down, but still he is at liberty to resort to the expedient of suspending weights from the ends of the levers which would avail him, and thus control would be lost.

2nd. It may be objected that if the driver is wishful to add to the pressure and elude detection by the pressure gauge, he can do so by shutting off its communication with the boiler. To prevent this, it is intended so to construct the cock communicating with the boiler that it can never entirely shut off the communication.

For the better and more easy comprehension of this improvement, a pressure gauge, constructed upon this principle, was exhibited.

OBSERVATIONS ON THE BEST MODE OF WORKING AND VENTILATING COAL MINES. BY J. BRAKENRIDGE, ESQ., OF SANDAL HALL, WAKEFIELD.

This Paper, which was illustrated by means of a large diagram of a coal mine worked upon the principle which it recommends, was prepared for the last meeting of the Society, at Barnsley, when Mr. Carter, of Halifax, read his paper upon the subject of ventilating mines. Having, however, mistaken the day of the Barnsley meeting, I consented to read this Paper now. Soon after the dreadful explosion at Lund-hill, in February last, I addressed a letter to Sir George Grey; and the present Paper is an elaboration of that letter. The following are the principal points of the Paper :—

The late fearful explosion at Lund-hill Colliery, with the awful destruction of human life and property caused thereby, furnishes another solemn warning to all interested in mining operations, or having the management of coal mines; and calls loudly upon the Government of the country, and upon every man of humane mind, to try to devise some means by which such dreadful catastrophes may, as far as possible, be prevented; and, at the same time, to provide for the pitmen the means of escape, should any such unfortunately happen. Having these objects in view, I have for some time past turned my attention to the subject, viz., a safe mode of working and ventilating coal mines, more particularly in the Barnsley or thick coal bed. This coal, as well as the strata overlaying it, gives out considerable quantities of inflammable gas (carburetted hydrogen), which, being nearly colourless, and extremely elastic and light,—its specific gravity being about one-half that of common air,—has a strong tendency, as soon as liberated, to rush upwards, and to accumulate in all the upper crevices and intricacies of the mine. Bearing in mind these characteristics and tendencies of the gas to be expelled from the mine by ventilation, and having carefully reconsidered the subject, I adhere to, and strongly recommend for adoption by coal proprietors, the general principles indicated in my letter on this subject, of the 9th April last, to Sir George Grey, the Home Secretary. These principles are—

1st. That before the coal is begun to be got from the *banks* or *wide works* of the mine, the *board-gates* or *air passages* should be driven through the coal to cross headings communicating with the furnace and up-cast pit placed at the extreme rise of the coal-field intended to be got by means of the same winning.

2nd. That the coal should be wrought down bank from the cross headings, so as to place the *goaves or wastes behind* the men, betwixt them and the furnace and up-cast pit, and thus, should an explosion happen, to ensure the means of escape through the passages in the solid coal to the drawing pit.

3rd. That a continuously ascending ventilation towards the furnace and up-cast pit is not only practicable, but is the only means by which the light inflammable gases can be expelled from a mine so as to render it safe.

These are the general principles of the mode of working and ventilating coal mines that I recommend. The first thing to be considered in opening a new colliery is the position of the pits—the engine, the drawing, and up-cast pits—in relation to each other, and with reference to the field of coal to be laid dry and wrought by them. The engine pit will of course be sunk at or near the lowest point of the coal field; and generally, unless obstructed by the locality or formation of the surface, it will be found most convenient to have the drawing pit within a short distance to the rise of the engine pit. Until the colliery is fully opened, and the up-cast pit sunk, the engine pit will serve as a down-cast and the drawing pit as an up-cast; but afterwards, when fully opened, and the ventilation through the up-cast pit complete, they should both be used as down-cast pits. The up-cast pit should be sunk, and the ventilating furnace placed at the highest part of the field of coal to be drained and wrought by means of these pits, engine, and plant. The next step is to drive the working, water, and counter levels, and consecutively the double board-gates, first the pit board and the north back board, and the double cross headings up to the furnace and up-cast pit, and then the other board-gates set out at such distances from each other as the convenient hurrying of the coal, the nature of the roof, or other circumstances may require. In the sketch I have prepared, the board-gates are set out 120 yards apart, they are each 2½ yards wide, and the pillar of coal betwixt them 16 yards wide. As soon as the levels, the pit board, the cross headings, the back boards and two of the others, the up-cast pit and furnace, are constructed, the ventilation will be complete, and the getting of coal from the banks, betwixt the board-gates already driven, may commence, and be carried on concurrently with the driving of the remaining board-gates. By driving the board-gates entirely through the coal to the communication with the furnace and up-cast, some time before the coal is got, a large proportion of the gas—one-half at least—is, by the action of the air and furnace, drained off from the "backs" and "vertical cracks" in the coal. These backs or cracks are nearly always north and south, and nearly at right angles with the dip and rise of the coal, and are intersected by the board-gates. These drifts, with a continuously ascending ventilation through them, I hold to be the best, indeed I may say the only means of insuring the safety of a coal mine, as with very small attention on the part of the bottom steward, no accumulation of gas can take place.

As soon as the board-gates are all driven, the regular getting of coal to the fullest extent from all the banks may be carried on; and I strongly recommend what is termed "long work" in wide double banks, and that the coal should be wrought downwards *from* the cross heading and up-cast pit and furnace. This mode of working possesses many advantages; by it much straight work is saved, and, consequently, waste of coal prevented; a much larger proportion, probably 20 per cent. or one-fifth more of round or best coal is got from the same seam, and a large saving altogether of the coal usually left as posts and pillars, and after the first fall at the commencement of a bank, the roof breaks or expands itself down more equally and quietly, causing less concussion of the gas that may be in it.

I do not recommend what are called pack walls, to prevent the roof coming down. I have frequently seen in collieries such an extent of these walls, as greatly to obstruct the circulation of air, and at the same time causing a serious amount of unnecessary expense. All I consider necessary is to build a strong pillar opposite each of the slits from the board-gates through the narrow rim of coal left on each side of the banks to preserve the board-gates open. These pillars strengthen the rims and keep the slits open for ventilation. The pitmen are protected by strong stanchions of oak or cast iron, according to the nature of the roof and thickness of the seam—generally three rows, the third or back row being drawn out by a crane and chain as another front row is being set. The roof and overlaying strata gradually breaks or expands itself down, one fall towards the preceding, into the space from which the coal has been excavated. When the coal of the board-gate pillars and of the sixteen yard bank betwixt them is wrought out, it is in the same manner "down bank,"—the gas being drained off, the ventilation, as in driving the "board-gates" is up one and down the other to the last. This mode of working greatly aids and simplifies the process of ventilation, because the course or stream of air is uniformly ascending concurrently with the natural impulse of the gas, as it is liberated from the coal, towards the furnace and up-cast pit, without any necessity of returning the current of air down the "banks" or "board-gates." And here I cannot abstain from remarking that the process of sending air up one side of a "bank" across the face and down the other side and at the same time through the goaves betwixt them, with the view of carrying off a light elastic gas, has always appeared to me to be alike contrary to science and the nature of things (I may add, it is many years since I heard an eminent mining engineer say it was alike contrary to science and to common sense), and I doubt that any mine containing gas ever was, by that mode of ventilating, rendered so safe but that, by a mistake or act of carelessness, it might have been at any time exploded. It could only be by forcing in such a strong current as to cause much inconvenience to the pitmen, and to induce them to counteract it by putting up or removing brettices as they frequently do.

The lightness and specific characteristics of the gas sufficiently indicate the mode and only means by which it can be completely expelled from the mine, viz., by a continuously ascending current of air or ventilation; and by the mode I recommend, the gas, instead of being, as at present, *driven upon the men* at the bank faces, is at once *carried away from them* as it is liberated from the coal. By this mode of ventilating, there is no necessity to travel the air so far as in the usual mode and practice, till it is overpowered by the gas, even till it becomes in itself explosive. Should, from any cause, which (the rules laid down being carefully attended to) I am, I confess, unable to foresee, an explosion take place, whether partial or general, it would be in the goaves, and its force towards the furnace and up-cast, and the men would have the ready means of escape down the "board-gates" in the solid coal to the drawing pit, instead of, as is generally the case under the present system, being cut off by the fire from the drawing pit, till even, if they escape death from the explosion, they are deprived of life by the "choke" or after-damp. There can be no doubt that a large number, probably one-half, of the lives sacrificed at Lund-hill was caused by "choke-damp." Again, by this mode a less quantity and force of air is required to keep the mine pure than by the ordinary mode, by which the gas can only be *forced down* the boards from the bank faces by an inconveniently strong current of air; whereas, by this mode, the air is not required to travel far against the bank faces, there is little danger of its becoming surcharged with gas, and the current is always ascending in accordance with the natural impulse of the gas. By this mode of working and ventilating, there is little or no danger to be apprehended from the neglect of trap-doors being left open or shut; the air is split, and sent up each board-gate just in the proportion required, by air gauges or splitters fixed in the counter level at the foot or lower end of each board-gate, and with these the hurriers or trappers have nothing to do. The only trap-doors the hurriers have to pass through is one fixed in the slit betwixt the counter and working levels, opposite each board-gate, and these are made to close of themselves as soon as the trams pass through.

In conclusion, Mr. Brakenridge entered into some calculations to prove that, upon these principles, a mine may be worked with a saving of expenses to the coal proprietors; and he asserted his entire confidence that those heart-rending scenes of destruction to the property and lives of our fellow-creatures, which we have recently had so much cause to lament and deplore, would, in a great degree, be averted.

At the conclusion of this paper an interesting discussion followed, in which

Mr. Carter said he quite concurred in the general principles of Mr. Brakenridge, and regarded it as a remarkable fact that Mr. Brakenridge and himself, though unknown to each other, should have been labouring simultaneously to develope a perfectly identical system of working collieries. Those who were present at the Barnsley meeting would remember that the paper he there read, enunciated a principle identical with the one now introduced by Mr. Brakenridge; but Mr. Brakenridge had now more fully and clearly elaborated the principle.

Mr. Briggs thought Mr. Brakenridge had not made any provision for "throws," or fractures of the stratum. A practical difficulty would be found in the 120 yards wide working. Each would require twelve men to work abreast; these men would be in each other's way; they would have to carry their coal across each other's ground; and thus there would be constant quarrelling. He thought the suggestion of carrying off the gas to the rise a very excellent one; still there were practical difficulties regarding its escape, of which he thought Mr. Brakenridge was not aware. In his (Mr. Briggs') colliery, they found the straight works a very great expense; but they were necessary for the comfort and safety of the men, and therefore expense was a secondary consideration. No doubt, the best ventilation was that of the cupola fire, but there was danger attending it—the danger that the men would allow the fire to go down, and thus stop ventilation. With regard to the question of propping the roof, they had found the requirements in one of his mines the very reverse of those of another. In one, when they took away the props, the roof fell close up to the working face; but in the other, the roof was so hard a rock that they could work 70 yards by 70 without a prop. Now, the latter roof was the most dangerous, because when it did come it brought with it an immense quantity of gas, which was liable to rush upon the men. That was a goaf which required ventilation: whereas, when the roof fell close, it was not necessary to ventilate the goaf. With regard to the direction of the explosion, the ignition of foul air at the cupola fire of a mine was like setting fire to a train of gunpowder, for the explosion would extend back to the farthest extremity of the workings. Then there was danger in the continuous working of a mine, because when, as at Lund-hill, a mine was worked night and day, and trap-doors were being continually opened, the current of air was as constantly baffled, and the air of the mine became in an impure state. Let that go on long enough, and an explosion, more or less extensive, was inevitable, especially when the return air was carried through the fire. Beyond all doubt, the principle of

Mr. Brakenridge was the best—that of going to the far end in the first instance, and working towards the drawing shaft, because the men were leaving the old workings behind them, and when they were escaping from an explosion there was a clear road for them to run, between the solid coal, instead of along goaves (or old workings) which were impregnated with explosive gas and choke-damp, which suffocated them as they ran. By the old system of working from the down-cast shaft, where one man was burnt by an explosion, from twenty to thirty were smothered by the choke-damp. Now, in his Whitwood mine, worked upon the principle advocated by Mr. Brakenridge, they had had no miners smothered, and the most they had ever had killed, were two or three at a time. He feared, also, that Mr. Brakenridge did not make sufficient allowance for the diffusion of gases. But these were points of detail; and he wished specially to impress upon the gentlemen present that the safest principle was to begin working the coal at the far end, and work towards the drawing pit, and not from it.

Mr. Crowther expressed his concurrence in the views of Mr. Brakenridge.

Mr. E. Brooke, Jun., objected to the suggestion that there should be advance drifts in front of each working, in order to release the gas in the coal to be worked, on the ground that these advanced drifts would not themselves be ventilated, and consequently would be likely to become reservoirs of gas. He regarded the principle of leaving the sixteen yards banks or pillars between the board-gates until the whole of the coal in the wide workings had been won as open to objection, and argued that the pressure of the superincumbent strata and the falling of the roof would render it impossible to get these banks at all.

Mr. Briggs said this was an objection, no doubt, not only from the falling of the roof, but also from the upheaving of the floor, which, in the course of time, would completely conceal the pillars so that they would not be able to get at them. In his colliery, they did not leave pillars of sixteen yards or sixteen inches; they took all the coal as they proceeded.

Mr. Brakenridge said these were necessary for keeping up the ventilation.

Mr. Briggs admitted it might be a necessity on Mr. Brakenridge's principle, but it was not even desirable on the plan pursued in his (Mr. Briggs') colliery. He might add that he concurred with Mr. Brakenridge upon the evil of carrying the return air through the cupola fire. At his colliery such air was carried from the mine by means of a dumb drift above the cupola fire.

Mr. Brooke observed that there were twenty doors in the diagram. Now he thought doors in mines most objectionable, as in cases of explosion they were blown down.

Mr. Brakenridge admitted that when doors were on the side of the workings next to the up-cast pit, they would be blown down, but not on the other side, where these doors were all placed.

Mr. Brooke said the force of the explosion had nothing whatever to do with the current of air. The force of the explosion was caused by the rush of air to fill the *vacuum* caused by the explosion itself; and, as would be seen, that force or rush would be in all directions, irrespective of the current of air passing through the mine.

Mr. Brakenridge remarked that the risk was not in having the doors, but in having them left open.

Mr. Brooke quite concurred in that; and it followed from it that the more doors the greater the risk of some being left open.

Mr. Jebson said his great objection to the plan was, that he did not see how it could be carried out in practice. He could not see the utility of placing the up-cast shaft at the extreme point of the estate to be worked; and the inutility of such a course would be the more apparent when it was remembered that many of the estates worked in the neighbourhood of Barnsley were—not 120 acres, as laid down in Mr. Brakenridge's plan—but 1,000 and 1,500 acres. Now, if they started at the engine-pit and pushed their working to the up-cast before they fairly began to get the coal, they would be very expeditious to complete that preliminary work in two years and a half. Now, that was precisely the most dangerous period of a mine, because of the difficulty of expelling the foul air, before they had got their straight work for ventilation completed. He thought, too, that Mr. Brakenridge had begun at the wrong end; because what was really wanted was, a means of ventilation which should put an end, as far as possible, to these constantly-recurring explosions in existing collieries. Instead of doing that, Mr. Brakenridge had confined himself to what he conceived would be the best and safest means of laying out and working a new mine. The first and great question was, how to put existing collieries in a state of safety with respect to gas? and when they had succeeded in that,—when they had succeeded in expelling the gas as fast as it arose, and replacing it with pure air,—all danger in coal mining would be over, even were the West Riding one vast goaf. The sixteen yard bank pillars proposed to be left by Mr. Brakenridge, would, before they were worked under that gentleman's system, be ground to powder and buried; and, instead of getting an improved quality of coal by the wide workings, all experience went to prove that they would get 20 per cent. less marketable coal from wide than from narrow workings. With regard to the safety of the miners in case of an explosion, in a mine worked on Mr. Brakenridge's principle, it was known that the concussion was always towards the place where the pure air entered the mine, and not towards the up-cast.

That being so, what became of Mr. Brakenridge's special safety of the men with the mine ventilated as he proposed? It would be no better than the present system. He thought it far better to place the up-cast shaft near the centre, and not at the extremity of the estate, where old works would have to be kept open for years for no other purpose than to keep open a communication with the up-cast. Another objection to Mr. Brakenridge's proposition applied to the principle of placing the down-cast shaft at the low end of the mine, and the up-cast shaft upon the rise, for experience told them that the deep shaft would always draw the shallow one, so that they would be under the necessity of not only forcing the air through the mine, but forcing it in a direction contrary to its natural course.

Mr. Carter replied at some length to the objections raised, and remarked that the very utmost they amounted to was this—that Mr. Brakenridge's principle contained some of the evils of the present system of mining. Such was the allegation; he contended, however, that it was not well founded; on the contrary (though the principle might be capable of further improvement), the principle now suggested contained some most valuable improvements, to which handsome testimony had been borne by Mr. Briggs, himself a colliery owner, who thoroughly understood mining operations. His own impression was that the principle laid down by Mr. Brakenridge was the only natural and safe one; it was founded upon the principle which they saw in operation in nature; and, if followed out, would have the effect of materially lessening the disastrous results of colliery explosions, if not of preventing them altogether.

Mr. W. S. Ward next addressed the meeting, observing, in the course of his remarks, that some fallacies were observable in the arguments on both sides. He warned gentlemen not to condemn or cast aside a valuable suggestion merely because it did not at the first glance appear to meet all the requirements of the case.

Mr. BRAKENRIDGE, in answer to Mr. Brooke and Mr. Jebson, said,—That by the mode I recommend there could be no gas in the lower part of the mine through which the communication with the drawing pit is kept up, no coal being broken down or got there, an explosion would not extend far in that direction—it would be very extraordinary indeed if it went beyond the bank in which it happened. The concussion is, no doubt, caused by the rush of air in consequence of the explosion, be it greater or less, but from the higher temperature and greater lightness of the air on the side towards the up-cast, as well as the existing current of air from the unaffected parts of the mine, the draught would soon be in that direction, and the trap-doors are all so constructed as to open in that direction, and not to resist the current. This advantage it is utterly impossible to obtain by the system of returning the air down banks, and back nearly to the point at which it is sent down into the mine. The only objection in which I feel there is any practical force is that in which a fear is expressed that the sixteen yards of coal betwixt the board-gates and the bank posts on the outsides of the board-gates, would, by the falling of the roof, be so crushed as to stop all communication with the ventilating shaft, and prevent that coal being got. Now, I admit the force of this objection; indeed it had occurred to myself after I had drawn the diagram. It does not at all, however, interfere with the principle, and the diagram is laid down exactly as I have seen the works in a mine of considerable extent. It has been suggested that I should reduce the sixteen yards to ten, and add three yards to each of the bank posts. I should not, however, do this, my principle being to get and ventilate the greatest possible extent of coal with the least possible extent of straight works. I should rather make the sixteen yards twenty, and the bank posts five or six yards each as may be deemed necessary. This would ensure safety from being crushed, and the principle in all respects remain precisely the same. The danger, however, is not so great as some of the gentlemen present seem to apprehend. The roof comes down very differently, and the pressure is much less on the rise than on the dip board. Another mode by which the apprehended danger may be avoided would be to work out all the banks on each side of the mine at once, leaving only the back board-gates on each side, and two banks, one on each side of the pit board. This would prevent crushing but not be so perfect in ventilation. The objection that the plan extends to 120 acres only, does not amount to anything. The diagram, according to the scale on which it is laid down, extends to about 115 acres, but it is merely for illustration, and not meant to represent the extent to which the mine may be wrought.

ON THE REMAINS OF AN ANCIENT BLOOMERY, AT LOCHGOILHEAD, ARGYLESHIRE. BY MR. KYLE.

The exact period when the ancient inhabitants of Great Britain first practised the art of metallurgy, as applied to the manufacture of iron, must ever remain a matter of uncertainty and dispute. We have the authority of Cæsar for stating that when the Romans under his command invaded the British Isles, they found the inhabitants making use of iron rings, or tallies, (taleæ ferreæ) as a substitute for coins, but which it is possible the aborigines may have obtained in exchange for tin, which at that time they employed during the process of bartering with the Phœnicians for different commodities.

Though then, it may be an open question whether the knowledge of smelting iron was possessed by the Britons prior to the time of the Roman invasion, or was introduced by the Romans themselves, this much is certain, that the birth of our iron manufactures may be dated from about that time. This appears demonstrated by the fact that ancient beds of iron scoriæ have been discovered, in which Roman coins have been found. These beds of scoriæ are met with in many parts of the country, more especially in England, in the neighbourhood of Birmingham and Sheffield, and are chiefly interesting as being so many relics which point out to the inquirer the precise spots where once the metallurgic art was practised; and, it may be, occasionally indicating to us the existence in their vicinity of stores of mineral treasure which, during the lapse of centuries, have been forgotten, or the working of which may have been abandoned from a scarcity of the particular fuel at that time deemed necessary for the reduction of the metal from its ore.

The object of the present communication is very briefly to direct attention to the existence of a bed of ancient scoriæ, which was discovered by me during the autumn of last year, at Lochgoilhead, a small village situated at the northern extremity of Lochgoil, in the western Highlands of Scotland. One day I chanced to pick up a small piece of a heavy, dark-coloured slag from amongst the protruding roots of some trees growing in an unfrequented part of a wood, near the shores of the Loch, and at the base of one of the mountains, the rugged slope of which is covered with large square masses of rock, and is known as "Argyle's Bowling Green." The occurrence of this relic of industrial art in a situation so far removed from any existing blast furnaces, led me, in conjunction with my friend Dr. Stevenson Macadam, to make a closer investigation of the neighbouring ground, near which the first specimen had been picked up. We were not long in discovering, at the depth of a few inches beneath the surface soil—now thickly covered with brushwood—great quantities of the slag, as also small portions of charcoal which had doubtless been the fuel employed in smelting the iron. Pieces of stone were likewise observed, which, from their calcined appearance, had evidently formed part of the rude structure which had served as a substitute for our modern blast furnaces.

It now became apparent that we stood on the site of an ancient "bloomery," though, on inquiry of the inhabitants of the district, we were unable to gain any information, historical or traditional, tending to confirm the opinion that the manufacture of iron had at any time been carried on in the district.

The slag referred to is of a blackish colour, is somewhat vesicular, has a vitreous fracture, fuses without much difficulty before the blow-pipe, and on analysis yielded to me the following results :—

Silicic Acid	29·60
Alumina	5·60
Lime	2·80
Magnesia	3·72
Protoxide of Iron	56·52
Sulphide of Calcium	1·00
Loss, with traces of Manganese and Phosphoric Acid	·76
	100·00

The above analysis represents a slag which is essentially a double silicate of alumina and protoxide of iron, together with a little lime and magnesia. The oxygen in the combined bases considerably exceeds that in the silicic acid, a fact which is the reverse of that generally observed in the analysis of modern iron slags; experience having shewn that the slag possessed of the highest degree of fusibility is that in which the proportion of oxygen in the acid is exactly double that in the base.

The composition of the Lochgoil slag is sufficient to show that the process of manufacture employed in this bloomery was, most likely, that known as the direct or Catalan process, one still adopted on the continent to a small extent, and by which method, the ore, either in its raw condition, or previously subjected to a preliminary roasting, is reduced to the metallic form by the direct action of the fuel and without the intervention of any flux, such as limestone.

The silicic acid present in the ore is thus compelled for the most part to combine with the protoxide of iron, giving rise to the formation of a slag of a highly fusible character, a matter of great importance when we take into consideration the simple and imperfect appliances at command of the operators in those remote regions and early times. It has long been remarked that the scoriæ found on elevated positions generally contained a large amount of oxide of iron, whilst those produced from bloomeries situated on less elevated districts, more closely resembled the slag run off from the blast furnaces of the present day, and had little iron in their composition. From this circumstance it has been inferred that, prior to the introduction of bellows as a means of forcing air into the burning fuel, the bloomeries were placed on positions as elevated as possible, where the natural currents of air could have more ready access to the combustible; notwithstanding this expedient however, the temperature thus attainable must still have been much less intense than where artificial methods were had recourse to for this purpose. Consequently the employment of lime with the view of separating the silicious matter of the ore was impracticable, the calcareous silicate thus formed being of too infusible a nature to admit of its being readily formed and run off from the furnace. Judging from the results of my analysis, and from these various considerations, I am led to the conclusion that the bloomery at Lochgoilhead was one of the most ancient in the kingdom, and although situated at no very great height above the sea level, its position would still be one well adapted for carrying on with success the manufacture of iron by the most primitive method, as through the valley, sudden and high winds are, in one direction or another, almost constantly sweeping. In concluding this notice, I may state that I have as yet been unable to prove the existence of deposits of iron ore of any extent, in the vicinity of Lochgoil, but I trust ere long to have an opportunity of examining the locality more fully.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FORTY-NINTH (THE ANNUAL GENERAL) MEETING, HELD
IN THE PHILOSOPHICAL HALL, LEEDS, ON THURSDAY, JAN. 28TH, 1858,
AT TWELVE O'CLOCK AT NOON.

THOMAS WILSON, ESQ., Vice-President, in the Chair.

Mr. WILSON, in opening the proceedings, remarked that James Garth Marshall, Esq., would have presided on that occasion, but he was confined to his house. He was sure that those present that day would all join with him in deeply regretting the loss the Society had sustained by the death of their first and only president, Earl Fitzwilliam. That nobleman took an active part in the business of the Society throughout its existence. Not only was he most liberal whenever the Society applied to him—offering as he did, the sum of £500 towards establishing a museum if it could be carried out;—but he attended the meetings and did everything to further the interests of the Society. He regretted very much to see such a small meeting that day in a town like Leeds, which was deeply interested in the objects of the Society. The council had it in contemplation to hold their next meeting during the visit of the British Association to Leeds in the autumn of this year, when they hoped to get together a number of gentlemen from all parts of Yorkshire who were interested in the Society. By that means, he hoped, would be brought about something like a revival in the activity and resources of the Society.

Frederick William Mowbray, Esq., consulting engineer, of Shipley; and Dr. John Le Gay Brereton, of Horton-lane, Bradford, were elected Members of the Society.

Mr. W. S. Ward, the Secretary, read the following financial statement for the past year:—

STATEMENT OF RECEIPTS AND EXPENDITURE

OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST RIDING OF YORKSHIRE.

From January 22nd, 1857, to January 28th, 1858.

DR.	£.	s.	d.
By Balance in Mr. Battman's hands	8	8	6
,, Balance in Treasurer's hands....	7	16	6
,, Subscriptions—			
From 1 Member for 1852	0	13	0
,, 1 ,, 1853	0	13	0
,, 1 ,, 1854	0	13	0
,, 3 ,, 1855	1	19	0
,, 28 ,, 1856	18	4	0
,, 88 ,, 1857	57	4	0
,, 1 ,, 1858	0	13	0
	£96	4	0

CR.	£.	s.	d.
To Collecting Subscriptions	2	7	4
,, Postages	2	6	8
,, Rent of Museum, on account ..	26	10	0
,, Messrs. Baines, on account......	20	0	0
,, Expenses of Meetings	2	3	0
,, Subscription to the Palæontographical Society for 1856-57 ..	2	2	0
,, Assistant Secretary, on account	25	12	0
,, Stationery	0	6	8
,, Lithographing and Etching and Printing Plates	3	16	0
,, Sundries	1	14	2
,, Deficiency in Mr. Battman's accounts	8	8	6
,, Balance in Treasurer's hands....	0	17	8
	£96	4	0

LIABILITIES.	£.	s.	d.
Messrs. Baines	30	12	8
Philosophical Hall	3	10	0
Salary of Assistant Secretary	21	8	3
	£55	10	11

ASSETS.	£.	s.	d.
Cash in Treasurer's hands	0	17	8
Arrears of Subscription	26	13	0
	£27	10	8

The Chairman then called upon the Secretary to read the first Paper,

ON THE DISCOVERY OF ROMAN REMAINS AT FILEY. BY DR. PRITCHARD, OF FILEY.

The discovery of a Roman Fort on the Cairn Head, immediately above the Brigg, has created considerable excitement in this lovely watering place—the rising

Brighton of Yorkshire. The exploration being announced to take place on the 12th and 13th of October, 1857, a great number of ladies and gentlemen assembled on the spot to witness the revelation of hidden treasure and ancient relics. Copious notes of the proceedings, measurements, &c., were taken by Professor Phillips and myself.

The Cairn Head is a narrow promontory or cliff, running out into the sea, and with a ridge of rock, with which it is connected, called Filey Brigg, extending half-a-mile further into the sea, forms the beautiful, expansive, and safe bay of Filey—unquestionably the *sinus salutaris* of Ptolemy. The site of the barrow is between the Spa-well, or the line of main cliff, and the extreme point of the Cairn Head, and it extends nearly across that part of the promontory where it is situated.

The recent heavy rains having dislodged portions of earth on the north side of the cliff, exposed to view some remains of a rude kind of masonry. Among the debris of the fallen earth were scattered portions of charred wood, bones, broken pottery, &c., which attracted the attention of Mr. Wilson, painter, who immediately brought some of the specimens to me. I repaired with him to the scene of the discovery, and unhesitatingly declared the remains to be of Roman origin, and forthwith acquainted the Rev. Richard Brooke, landlord of the estate on which the barrow is situated. He fortunately being in the neighbourhood, on his accustomed visit to Scarbro,' promptly determined to have the place further and effectually examined. This was accordingly done, as we have before stated, on the 12th and 13th of October. Mr. Elders having directed the excavators to their task, they soon came upon an object of interest—a large tooled stone. In a line with this, close upon the edge of the cliff, they found another about 15 feet apart. They then began operations in parallel lines from these, and at twelve feet distance they found other two stones of similar construction; and in the centre of this parallelogram was found another stone somewhat larger than the rest. These stones were all set in mortar, on a bed of puddled clay, several inches in thickness. This puddled clay formed a floor for the whole surface, bounded by the stones, and on it were found the various remains, such as Roman pottery and coins, ashes, and charred oak beams. Some of the remains gave evident proof of the action of fire. Over the whole surface were found large quantities of broken earthenware, bones of pigs, oxen, sheep, dogs, and deer. The upper and lower stones of a small hand mill or quern were found; their diameter was about two feet. These also had been subjected to the action of fire. The five stones that were found were nearly square, averaging about one foot eight inches in height, and diminishing by two steps to the top; each "set-off," as it is technically termed, being rather more than two inches. The bases are rather over two and a half feet square—the tops little more than one and a half feet. The centre stone, as we before remarked, is the largest, and moulded at the bottom "set-off." In the middle of the top of each is a socket seven inches square and three inches deep. In the present incipient state of the examination it is difficult to imagine the precise object of these stones. Whether they have formed part of an altar, a signal or watch tower, a Roman villa, or a General's head quarters, we hardly dare hazard a conjecture; but the Roman origin of the structure is placed beyond doubt, by the coins bearing the names of Constantine, Claudius, and Nero. There is every probability that the whole of the surface of the promontory is full of Roman remains, and would, on careful examination, yield a far richer harvest of antiquarian fruit than has hitherto been gathered.

On the 19th instant, and during the subsequent week, further explorations were prosecuted with diligence, when coins, more pottery, part of a sword, a stone battle-axe, broken rings, arrow and spear heads, and animal bones rewarded the researches.

Surrounding the position of the stones already mentioned, the foundation stones of a wall, four feet in thickness and about fifteen feet distant, running in a south-east direction, was laid bare, but not followed up to its termination. And also another trending in a north-easterly direction, likewise not explored, occupying the same distance and apparently for the purpose of supporting some superstructure, but what that was it remains to conjecture, and no trace beyond the layer of stones and mortar has been found.

In an old work on the antiquities of Filey, by one John Cole, I find an allusion which runs thus:—"A stone, of which we give a representation, was dug up at a place called Raven Hill, on a high promontory, named Peak, near Robin Hood's Bay, the inscription on which demonstrates the existence of a Roman Fort at that place, probably belonging to a chain of Forts erected along the coast to repel the incursions of the Saxons, and other pirates. Besides the Fort at Dunsley, guarding the landing place at Sands End, there was probably a Fort on Whitby east cliff to defend the harbour, another at Scarborough castle, 'one near Filey Bridge,' and one at Flamborough Head. The inscription on the stone ran thus:—

"ivstinianvs. P.P.
Vindicianvs.
M.A.S.B. iter. w. P.R.
M. Cæstrum. Fect.
A.C.O."

Which, translated is:—"Justinian, governor of the province, and Vindician, general of the forces of upper Britain for the second time, with the younger provincial soldiers built this Fort, the manager of public works giving his assistance." I inserted this paragraph in the shape of a letter to the editor of our local paper, and the following is an extract of remarks made upon it:—"Our valued correspondent, Dr. Pritchard, mentioned the Fort at Dunsley. The editor of the *Archæological Mine* says this name is of Celtic origin, and is derived from *Dun*, a height, and *Ley*, meadow—thus, "the meadow" or "pasture land on the height;" whilst the etymology of Fi-ley is "the cultivated land." Cairn Head is again singularly expressive of a mortuary memorial. In fact, when we look at the etymologies of our district, we find them, one and all, of Celtic origin, and significant of position or of some peculiarity.

I should not omit to mention that on the centre stone (of the five peculiar ones already described) a rudely carved stag, followed by a dog or wolf, was in a good state of preservation on the south upper step of the stone.

The site of foundations and depth of the floor of the structure was buried four feet beneath fine mould and clay, very little unevenness of the earth's surface marking the position of the remains; and yet there does exist a kind of indentation as of an old ditch or fosse, dividing the promontory from the main land. The last coin found had "Titus" distinctly upon it, also one of "Augustus Severus," in plain characters. I regret the excavations have been brought to an abrupt termination for the present, but we hope to renew them another year, not more than one-fourth of the barrow having been opened. Some of the pottery we have reconstructed into its original form. The last found vessels had all the marks of those described as being found at Pompeii,—the bright red earthenware.

The immense accumulation of animal bones is difficult to account for. So far, I have made out those of sheep, deer, wolf, fox, fowl, (especially several cock spurs and legs,) in good preservation, ox, horse, and the relics of shell-fish, oysters, limpets, and cockle, and undoubtedly some human bones, more especially those of the fore-arm and fingers, but no others.

I hope these imperfect notes may afford instructive discussion among your learned members which may solve the mystery of these ancient productions. I would only venture to offer mine, that this has been undoubtedly "a Roman military out-post," one of the guard stations of the coast.

I hope at some future time to thoroughly examine the whole place, and venture to promise a less hasty and more lengthy paper.

AN ACCOUNT OF SOME EXPERIMENTS WITH THE STEAM JET AS A VENTILATOR FOR MINES. BY MR. F. H. PEARCE, C.E., OF BOWLING, NEAR BRADFORD.

A few months ago, the writer's attention was drawn to certain alterations required in the pumps employed in draining a small colliery in this neighbourhood. The shaft is about 120 yards deep, and the nature of the alterations was such as to put a stop to the working of the pumps for some time; during this stoppage the water accumulated in the workings of the mine, and ascended some distance up the shaft, thus completely stopping the system of ventilation previously employed.

The ventilation of the pit had no sooner ceased, than the accumulation of carbonic acid gas (or choke damp) rendered it impossible for the workmen to proceed. Several attempts of an ordinary character were made to displace the gas but they did not succeed, and there appeared a probability of having to incur some expense before proper ventilation of the pit could be accomplished. Matters remained in this state for several days, and further attempts were made to get rid of the gas, but still without the desired effect. The completion of the pumps now became urgent, and therefore, the removal of the noxious gas indispensable.

After careful examination of what had been done, and finding it all practically correct, and such as had before been found sufficient for the purpose in most ordinary cases of a similar nature, the writer determined upon trying the effect of a jet of steam, the application of which happened to be exceedingly favourable; and the result was the most complete success; the men were enabled to descend the shaft immediately, and from that time the repairs proceeded, and were completed without the slightest delay or inconvenience from imperfect ventilation. The powerful draft produced in so simple a manner caused the most experienced workmen to regard the steam jet as something extraordinary, and to say the least of it, it was indeed found to be a very useful and efficacious expedient. The writer was previously aware that steam had been employed for the ventilation of mines, many years ago, but he had no knowledge of its ever having been used in the way he applied it in this instance, though he has been subsequently informed of prior and somewhat similar applications attended with equal success. Such applications, however, are by no means common in this district, though there are frequent instances where they may be found exceedingly useful, and this can only be accounted for by the fact that very few of our operative miners are sufficiently acquainted with the capabilities and simplicity of the steam jet ventilator.

It was the writer's intention, after receiving an invitation, to submit to your Society a paper on this subject, but subsequent experiments, made on a small scale, with a view of ascertaining its comparative economy, having convinced him that the steam jet principle cannot be advantageously employed to any considerable extent for the ventilation of coal mines, he respectfully declines that honour, and prefers giving a brief account of what little he has done in the matter, so far as it appears to him at all likely to be useful to others, which he trusts will be received as a substitute for a paper.

The manner in which the ventilation was effected in the pumping shaft above referred to, may be described as follows:

The shaft, as before stated, is 120 yards deep, and the pump is divided into two lifts; the lowermost lift is effected by means of a working barrel and bucket of ordinary construction, situated a few feet from the bottom of the pit, which delivers the water into a cistern about midway up the shaft. The upper lift is effected by a ram or plunger working immediately above the cistern from which it draws the water, and forces it up a main of seven inches cast iron pipes, which reach the top of the shaft where the water is delivered into an open reservoir. Near to the top of the seven inch main a temporary connection was made with another pipe of the same diameter, and nine feet long, placed vertically; and into the lower part of this pipe was conveyed a piece of $\frac{3}{4}$ inch common gas pipe, with its end turned upwards, the other end of the gas pipe being connected to the steam boiler, close at hand, by means of a stop-cock. This simple arrangement constituted a most perfect ventilating apparatus, the effect of which appeared rather extraordinary. The quantity of steam passed up the interior of the seven inches pipe, from the jet piece, was regulated at pleasure, by means of the stop-cock near the boiler; and thus the ventilating power of the jet could be increased or diminished to any desired extent.

It should be remarked that the workmen had partially removed the clack-door at the bottom of the rising main before the accumulation of damp had stopped further proceedings, and it was through this aperture that the ventilation was effected. The pressure of steam in the boiler was 20lbs. per square inch, and on opening the stop-cock, the velocity of gas, &c. drawn up the pipes was such that a few minutes sufficed to clear the pit of foul air down to the clack-door, and the remainder was effected by attaching temporary wooden pipes.

After observing the rapidity with which the air rushed up the pipes, and finding that only a comparatively small supply of steam was necessary to maintain thorough ventilation of the shaft, it was determined to apply the same principle to ventilate the workings of a small neighbouring colliery, in which not more than ten or twelve persons were employed underground. In this instance the shaft is about sixty yards deep, and the ventilation had been effected by means of wooden air pipes, communicating with the engine chimney, the draft of which constituted the ventilating power. The ventilation was feeble, and at times almost imperceptible, owing to the unfavourable state of the atmosphere; and the circumstance of the case, in other respects, being favourable to the application of the steam ventilator, similar to that already described, a nine feet length of ten inches cast iron pipe was fixed upon the wooden air pipe leading from the pit to the chimney, and the steam jet supplied from a boiler close by was fixed in it; there was also a slide or damper, placed between the cast iron pipe and chimney for the purpose of stopping the communication with the latter. The orifice of the jet piece was 11-16ths of an inch in diameter, and the boiler pressure ranged from 20 to 30lbs. per square inch. The effect produced by these alterations was a most decided improvement in the ventilation of the mine, and although it has been found inconvenient to keep the apparatus constantly in operation, owing to the consumption of steam, it is, nevertheless, found to be very useful at times, and is always employed in the morning before the men descend the shaft, for giving a good brush through.

It will be observed that the additional parts required in the application of the jet in this, as in the preceding instance, are very simple, and that the apparatus can be used or not at pleasure, by simply reversing the dampers, and opening or shutting the steam tap as may be required.

The effect produced by the chimney itself is pretty good, considering, but on opening the damper, while the jet is in operation, it presents a striking proof of superior draught—the smoke and soot are quickly drawn from the former, and thrown out of the iron pipe with the steam. The results obtained in this case, however, were not at all in accordance with the expectations raised by the apparent success of the former application. The leaky condition of the wooden pipes and other defects were certainly unfavourable, but even with ample allowance for these imperfections, the volume of air drawn through the circuitous course of the mine was by no means satisfactory in comparison with the quantity of steam expended on the jet.

A number of experiments were therefore commenced with a view of forming an approximate idea of the value of this plan of ventilation, as compared with others more generally adopted, and the results were most decidedly in favour of the latter; indeed the expenditure of steam was at once found to be so disproportionate with the useful effect, that there appeared little inducement for further inquiry.

The following is a brief summary of some of the results obtained, with three different jets, viz., a common round jet of 4-10ths of an inch area, and two annular jets, one of an inch and a half diameter, and the other of two inches and an eighth diameter, but both orifices being of the same area as that of the round one.

BOILER PRESSURE 28lbs. PER INCH.

AREA OF EACH JET 4-10THS OF AN INCH.

DESCRIPTION OF JET.	Velocity of air in wood pipes per minute, in feet.	Quantity of air discharged per minute, in feet.
Round Jet…………………………	1,100	1,650
1½ inch Annular do.…………………	1,320	1,980
2⅛ do. do.…………………	1,500	2,250
BOILER PRESSURE 40lbs. PER INCH.		
Round Jet…………………………	1,330	1,995
1⅓ inch Annular do.…………………	1,600	2,400
2⅛ do. do.…………………	1,810	2,715

The steam was supplied from a Cornish boiler of about twenty horses nominal power, but no steps were taken to ascertain the exact consumption of fuel, or the quantity of water evaporated. The firing, however, was such as to shew that the jet with twenty-eight pounds pressure, absorbed about half as much steam as the boiler was able to produce, and with forty pounds pressure, about three-fourths; and the consumption of fuel would probably be one and a half hundred weights, and two hundred weights respectively per hour.

On referring to the above tabular statement it will be observed that although the jets have the same area of aperture, they show different results; that of the annular jet being better than the round one, and the large annular jet still better than the smaller one. It was not ascertained to what extent the enlargement of the jet could be advantageously carried, but the size named gave a decided advantage. The annular orifice can be increased or diminished in area by simply turning round the internal cone, at the bottom of which a screw is formed for the convenience of adjustment.

The preceding results give an approximate idea of what may be expected from the steam jet under similar circumstances. In adapting the principle to the entire ventilation of a colliery of considerable extent, it would be found necessary to employ several such annular jets as the one described. It should, however, be borne in mind that in carrying out the plan on a large scale, a more suitable and convenient arrangement might be adopted. For example, the jets may be applied directly over the upcast shaft, and instead of using several small jets, one only, of suitable area and enlarged circumference, may be used. Such an arrangement would no doubt answer well, and may possibly be adopted with advantage under particular circumstances, but the consumption of fuel and expense of boilers would be great in proportion to the amount of ventilation produced.

ON THE VENTILATION OF MINES. BY MR. J. JEBSON, MINING ENGINEER, MOLD GREEN, NEAR HUDDERSFIELD.

This is a subject which has excited almost universal attention, and its importance demands the most earnest and patient study on the part of all who are interested in the matter; and though it has been investigated and much improved by the learned and most eminent men in science as well as practice, yet there is room for further progress; and where human life is endangered, there skill and science ought to co-operate, and be brought to bear to ensure safety. The perseverance and industry already bestowed on this all-important subject has not been in vain, as would be more clearly seen if we were to compare the present state of ventilation in mines, and the mode of working in general, with what it was twenty, nay, even ten, years ago; not that we have yet by any means attained to a system of perfection. The almost constantly-recurring explosions in mines fearfully remind us there remains yet much to be done before the desideratum in this respect is accomplished. But what is it that makes the difficulties so great in the way of achieving what is admitted by many, and lamented by all, as being essentially necessary to prevent explosions in mines? Diversity of opinion, prejudice, and (I wish it to be understood when I use the term, I mean it is not intentional) ignorance combined, have formed, hitherto, an almost insurmountable barrier. It will be necessary to inquire, first, to what are all the dreadful events that have been so destructive to life and property in mines to be attributed?

As to the direct cause of an explosion of carburetted hydrogen gas in any mine, there cannot be two opinions, simply because the gas does exist, and a light being introduced into the explosive mixture it must necessarily ignite. But as to the secondary or producing cause, opinions are wide as the poles. Perhaps the following are the principal causes: first, sudden and extensive eruptions of gas from the roof or floor, or from the coal; second, accumulated gas in goaves or old workings; third, gradually liberated gas in the actual workings of the mine. Eruptions of gas in a sufficient quantity to cause an explosion are of rare occurrence, and are almost exclusively confined to deep mines, simply because there is no natural or artificial communication with the atmosphere or surface of the ground. In mining operations cavities are found to exist in which such gas is confined until liberated by underground workings or sinkings. In case of an eruption to any extent, an explosion is almost certain, without the greatest care and a powerful current of pure air to dilute the gas emitted. To accumulated gas in goaves or abandoned workings, (I use the expression advisedly) most explosions have in the past been attributed.

Again, it is often asserted that the state of the barometer has much to do with the liberation of gas, or confining it in these goaves or old workings. I am not prepared absolutely to admit or deny that there is any close connection between the atmosphere above ground and below; but I think it is a delusion to suppose that the variations of the barometer are sufficient of themselves to liberate gas under ground in quantities to cause an explosion, especially in deep mines, in the presence of moderate ventilation. But in the absence of a current of air in shallow mines, and where the gas has been drained off or its native force exhausted, then the state of the barometer might affect the otherwise passive mass. Liberated gas in the actual workings is very varied in its effects, sometimes it escapes gradually and is easily managed, at other times its power is demonstrated by the force with which it displaces the coal, floor, or roof of the mine. This is beyond doubt the most dangerous state in which a mine can be worked, especially when a large surface is being continually opened night and day. It is to this state more particularly that the attention of all who are entrusted with the management of mines (and also valuable lives and property) should be directed, as it is universally found that all strata, and especially coal, is more or less open, or has cavities or cleavages out of which the gas is continually issuing. When an extensive mine is in progress of opening, many thousands of these natural drains are pouring their contents into the open space, under a pressure, as compared with the atmosphere of the mine, with which there is really no comparison. Under these circumstances one of two things is certain, either the gas emitted must be diluted and expelled from the mine, or there must be an explosion; and I have no hesitation in avowing that it is to this cause alone that ninety-nine out of every hundred of the explosions in mines are to be attributed.

The escape is constant and never ceasing for one moment, and so should be the antidote.

To prove that such is the case, we quote the fact, that in a mine which had stood for a few weeks and was allowed to be immersed in water; when the water was lowered in the shaft to a certain point, the gas rolled through the column of water in such force that an eye-witness declared it was like packs of wool rolling up, or like the fury of the waves of the sea in a storm, almost instantly filling the open space in the shaft with inflammable gas. This clearly proves that though man may be supine, the enemy is at work, and to this constant emission of gas under great force or pressure, we *repeat*, we fear we must look for the true cause of most, if not all, the explosions which occur in mines. But it is to be lamented that in all cases where the sacrifice of life has been great we have been left to conjecture as to the immediate cause of accumulation and ignition, as the only parties who could have solved the problem have invariably been cut off and have perished with their unfortunate companions in toil. It is true, therefore, that it is difficult to discover and establish absolutely and beyond a doubt the true source and issue of gas when explosion ensues, as no living witnesses remain to affirm the fact. From this cause, certainly, a degree of obscurity hangs over the immediate cause of these events, but the preponderance of evidence, we think, is greatly in favour of the opinion here expressed. From what has been already stated, we think there can be no doubt that these appalling calamities suggest the necessity that something more must be done to avert them; and presuming that either want of air or an improper distribution of it, or both, are the primary cause of explosions, it will be proper to inquire from what that want arises, and we incline to the opinion that the mode of laying out collieries has a great influence on the ventilation; not that we advocate new and complex modes of working or ventilation, or more ingenious or curiously constructed safety lamps. We consider these as mere trifles in comparison to the vital question. The colliery interest and trade of South Yorkshire is an increasing one, and is likely to become more so when fully developed. As yet it is in its infancy, and it is essential to its success that the mode or system of working should be on the most improved, simple, efficient, and economical principle; and as the ultimate object in working coal is to get as much out as possible, then the question arises,—Which is the safest and cheapest mode of working and ventilating a colliery? We think it is quite possible for danger to be warded from a mine by superior skill and untiring vigilance in carrying out the best methods already known. We have, for instance, the Pillar workings of the North, and the Longworks of the South or Midland Counties. Very similar in many important points, these are the two principal systems, the others are only modifications; but in Yorkshire, as well as other places, we incline to the opinion that the defective or worst parts of these systems only are adopted in many collieries; more especially when we consider that method characterised recently as the most dangerous, most wretched of all others, and which we believe is now almost universally condemned by mining engineers, viewers, &c.: we refer to the practice of conducting the return air over the furnace as one part of it. And we think that any proprietor, engineer, or viewer who persists in retaining that dangerous and highly reprehensible system in mines—generating gas, which by the clearest evidence is proved to be unsafe, is not only bold but reckless of both property and valuable lives, and all such ought to be held responsible for any loss that may accrue to either from any such events, which could not be accounted accidental. But though improvements in many places have been adopted in respect to the construction of the furnace, and conveying the return air out of the up-cast shaft, we fear many cling to established practices with a tenacity worthy of a better cause. Yet this is not all that is required. The method of working coal mines, and especially the one adopted and in use in many collieries now working the Barnsley Thick Coal is another part of the wretched, dangerous, and imperfect system. We think, as we have already stated, that the plan on which collieries are laid out, influences the ventilation materially. On that account the method in question merits all that can be said against it, and no terms are capable of sufficiently condemning the plan or mode of working that has hitherto prevailed on what is called the following up benk principle; and I should hold that no mine where gas is generated to any extent and worked on this system, is, or can be made, safe and secure against explosion. I have had full proof of what I here assert in my own experience, and I come to this conclusion for the following reasons: the benks, or wide-works are commenced from the benk level so called, and when an obstruction takes place at the working face, or in any of the roads, which is frequently the case, as I have seen the air course so obstructed, it prevents a free passage, and in many instances almost suspends the ventilation over perhaps one half of the workings of the mine; and, no matter what vigilance and care is exercised, these obstructions do and will occur from causes over which there is no control. On this ground it is essential that these emergencies should be met, and in all cases there must be a provision that if an obstruction occurs in one part of the workings of a mine that the course of the air in the full current may be maintained in every other part of the workings. Another of the evils of this system is the number of trap-doors, which ought—not only from safe and prudential considerations, but in a commercial point of view—to be avoided, and we think it is quite possible, as we shall shew, to obtain efficient ventilation without this hitherto necessary *evil*, for we are forced to the conclusion, when trap-doors are multiplied, they become excessively dangerous, impede ventilation, and are also an intolerable nuisance. We propose to dispense with many of them. We would further notice the prevailing practice of bratticing in ventilating straight work; not because it is dangerous in itself, but because of the manner in which it is generally carried out: it forms an obstruction intentionally, fixed by design, and it is recommended and used by men in many respects intelligent and clever, but what is the effect in practice? That the passage through which the air travels is reduced to about one half its proper dimensions, and instead of a proper area being maintained through all the workings of the mine, and uniform with the levels or intake, these successive obstructions and reductions combine to bring about results the most fearful, and render it absolutely impossible to supply a sufficient ventilation where this practice prevails; as all air roads should be free as far as possible from irregularities and obstructions, and as large an area maintained—or, indeed, larger in the return than in the intake air courses, on account of its increased density.

Another important feature in good ventilation is that there be as few communications as possible between the in and out going air, as these are most destructive to the current of air, as every door and stopping destroys the force of the current, more or less, through leakage.

Having pointed out some of the evils of the existing system, (to enumerate them all would take up too much of your valuable time) in summing up, we claim a little indulgence if we assert that the want of sufficient air, of ventilating power, obstructions in air passages, bad methods of conducting air through the workings and out of the upcast shaft, ignorance of the real necessities of mines, and a false economy, have been at the root of all the evils that have befallen miners and proprietors. In the hope that the future may be productive of something adapted to the real wants of the case, we proceed to notice the many improvements, so-called, for ventilating collieries, as well as suggestions for almost every conceivable theory that has been circulated through the medium of the press. Parties have indulged in speculations, and practice has not been idle, yet no general method has been devised to which all could subscribe. All agree as to the necessity of something being done, more especially since the disaster at Lundhill, nearly twelve months ago. This explosion is unequalled in the annals of mining history, and is only surpassed, I believe, by one existing colliery, in the number of human lives that have been sacrificed by this destructive element. But in one case the colliery had been in operation nearly seventy years, the other about five years. But are colliery proprietors, engineers, viewers, and colliers, yet fully aroused to a sense of the dangers to which every moment life and property are exposed in all ill-regulated and ill-ventilated mines, as in the South Yorkshire and other districts. It is to be feared there is danger in many instances of parties falling into a state of apathy and indifference, peculiar to mankind, to be awoke to a sense of the danger they are every moment exposed to, only by a sad event that takes away many at a stroke; and each succeeding explosion, experience proves, is more fearful and fatal than its predecessor.

From a desire to bring about a better state of things, two papers, by highly respectable and intelligent gentlemen, have been contributed to this Society on this subject, and considerable discussion has followed the reading of the same, in which many deeply interested in mining operations have taken a part,—I refer to the papers of Messrs. Carter and Brakenridge. I wish to avoid any observation calculated to convey the idea and impression that I do not fully appreciate the efforts they have put forth; and I hope the most valuable results will follow from the plan they unitedly advocate, for I believe their views are entirely in unison, and I presume I should not be wrong in stating that they have the support of many respectable proprietors; inspectors, engineers, and viewers; and, indeed, there cannot be any objection to the method they advocate, designated ventilation on the ascending principle, when viewed in the abstract. I regard it entirely as an abstract proposition, but it is at present very generally adopted, especially in deep mines, where much of the coal has to be won from the dip of the working shafts; but this they do not recognise, they advocate the up-cast shaft on the extreme rise of the estate, however extensive; this was the case in Mr. Brakenridge's plan. Mr. Carter did not accompany his paper with a proposed plan for working, but I think I shall be right in stating he fully concurred in the system proposed by Mr. Brakenridge; and the objections, I think, were chiefly raised on the details of the plan exhibited. But, perhaps, it will not be saying too much that it is altogether impracticable. For my own part I never could see any decided advantage in the principle itself; the difference, if any at all, is simply in the power required to force the requisite current of air to any given point or workings in the mine, whether it be the extreme rise or dip, and whatever may be the plan of working, the principle is the same. It is a question of distance, area, and power. As there will not be two opinions on the fact, that the gas, in a passive state, must be moved and carried off, and as the tendency of air is from the shallower to the deeper shaft in natural ventilation, I could not suppose a greater fallacy than Mr. Brakenridge's principle, that the up-cast shaft could become a natural drain, and draw off the gas merely because it was placed on the extreme rise of a coal field. It is true that the workings on the outcrop of coal are outlets, but the drain from a shaft simply is very limited; as, indeed, however great the pressure of the gas emitted from the coal in the mine, there must be sufficient barriers to support the main roads leading to the up-cast shaft, as well as to all the workings in operation, or the shaft itself would be of no use. The coal could not be worked out, and throw all the workings open to the up-cast shaft; this would close the shafts and roads. Then what becomes of the ascending principle? for when the goaves are formed, they are invariably the highest part of the mine, and the gas being lighter than atmospheric air, rises to the highest part, but does not as a whole escape to the up-cast shaft, only such portion as is forced out by the pressure of the gas emitted, such pressure being greater than the resisting force of the atmosphere by which it is surrounded. The goave forms an extensive reservoir of inflammable gas that has no way of escape except by ventilation, which is simply impossible and unnecessary in perpetuity, whatever the principle of the said ventilation may be. But, on the ascending principle, the greatest danger is to be apprehended from the fact that if the coal is worked from the rise to the dip, and no pack walls or pillars are left, the fall of the roof and ground-sweighs, so called in the thick coal, would be constantly forcing the gas from the goaves on to the men at work; and, mixing in the air in the separate setts, would pass from place to place, and the slightest derangement in the safety lamp would be fraught with the direst consequences, and on this ground alone would defeat the end proposed. Besides, working coal from rise to dip in a commercial point of view, would be attended with considerable danger, inconvenience, and loss, both in coal and timber; the weight would constantly be on the face of the coal where the men were at work, and the said weight would grind the coal, so that one half of it would be slack, as it is no uncommon occurrence even in mines three to four feet thick, when the weight is on, to break over the coal for yards, force the gas out in such quantities as to foul the air, however strong the current, and shut up the workings for the time being, however well packed or puncheoned. I therefore regard Mr. B's. plan of working coal as utterly impracticable, and hope that some plan may be devised less objectionable and more simple to work from the dip to the rise, both safe and economical. A modification of the longwork principle, where practicable, affords the desideratum; and I have endeavoured to show how I think it is quite possible so to lay out and work a colliery, by clearing out the coal from board-gate to board-gate where longwork is not practicable, but avoiding following up benks in all cases; also to leave the benk-level open for the air, that should any part of the workings be obstructed, there might be a free course. I further propose sheets instead of doors at the bottom of every benk, so that the air will always have a clear course if any or even all the benks are stopped, and on this principle the whole of the coal is cleared out, or nearly so. The pack walls are a sufficient support for the roof, and thin pillars could be left if necessary. This plan would not admit of heavy falls of roof, but a gradual sinking would take place until the space was filled almost as solidly as it was before the coal was worked; and if the gas is forced out it is principally *from* the men at work, not *to* them. I further provide that fresh air shall be conducted through such workings, and be conveyed to the up-cast shafts, without passing on the main hurrying roads, or being allowed to come in contact with any of the people employed in the mine. To effect this I have endeavoured to shew how the return air can be successfully conveyed into the up-cast shaft, and also what part of a coal field is the most proper for the said up-cast shaft; as, in my judgment, the situation is of some moment, not as compared with the main question, which is that it be of sufficient capacity wherever it may be placed, also of ventilating power adequate to the workings in operation, both shafts being of sufficient dimensions to admit the required quantity. On this subject we are not without data, though very imperfect, as I believe I should be right in stating on this question of power that one ton of coal consumed in a furnace in twenty-four hours would, under ordinary circumstances, produce on an average 20,000 cubic feet of air per minute, allowing for unequal depths of shaft or length of air-courses and other inequalities; as it is proved, I think, beyond a doubt that 190,000 feet of air have been passed through one heated shaft in one minute, also that air can be passed through a shaft at the rate of twenty miles an hour, and along the underground passages at the rate of fourteen miles an hour; and to produce these results the temperature does not require to be raised to more than from 170 to 200 degrees Fahrenheit. Put such a force as this into operation in the Barnsley Thick Coal, and what would be the quantity of air forced along? Why, eight years ago, about 31,000 feet of air in one minute was the largest quantity found in any mine in Yorkshire, and 40,000 the largest in Derbyshire. Both these mines were under the direction of J. T. Woodhouse, Esq., who appears to have been the pioneer of improved ventilation in these districts; and now a few may be found with near 100,000 feet of air passing up the up-cast shaft per minute; but much more than this can be effected by the up-cast shaft being even in the centre of a coal field and near the down-cast shaft, and the furnace on the dip side. Though there is no doubt a limit to the furnace, as a creative power, yet that has not been tested, simply because an enlarged area and increased furnace arrangements have always produced a correspondingly greater quantity of air; and I am of opinion that the furnace on the dip side of the up-cast shaft not only secures its safety in all contingencies, but also gives it greater power as a ventilating agent. I would further arrange that the furnace be supplied with fresh air from the down-cast shaft direct, and take the return current into the dumb drifts from the furnace. I propose to convey the return air by over-throws, and construct them on such a principle as to resist any force that could be brought to act upon them.

It will be seen that I propose, for working a large coal-field, to have only four main currents or divisions, two north and two south; more may be a matter of arrangement. I propose further that these divisions for the ingoing air shall take place at the bottom of the down-cast shaft, and shall be regulated in the return at an over-throw on each side, north and south; and as there will be two currents of unequal length on each side, the regulators must govern them. I think it possible to ventilate successfully any mine with four main divisions; there may be more at the discretion of the viewers, but I should require six when the coal is worked on the dip side of the shaft. I propose, further, that the up-cast shaft should not be less than twelve feet diameter, that would give an area of 113; the same in the down-cast; and as shafts are a great expense to open, and subject to the influx of water, it would be wise in all deep mines to have them large enough. To commence with an area of 113, would give in four equal divisions, twenty-eight feet to each, and would require six tons of coal in twenty-four hours to produce a column of air through the up-cast shaft of 112,000 feet per minute; and assuming the data on which these results are based to be correct, this would also give to each division in the working 28,000 feet, at a velocity of 560 feet per minute. This would be sufficient for most of the large collieries in the South Yorkshire coal-field, and could be arranged, according to circumstances, as to sub-divisions, &c. &c. The currents could not be much diminished, except by friction, if the area of fifty feet were maintained in each division in the workings—as there would be little loss from leakage, the barriers being throughout the whole circuit of the air, of solid coal, except at the over-throws—and in order to provide for this there would be an extra level the whole distance, five being necessary for the first division; but I think this is preferable to the risk of the stoppings being blown out should an explosion take place, and would not incur much extra cost, as the coal got out would pay for the yards in strait work. I think that what is here proposed is easy to effect in every existing colliery, the over-throws and dumb drifts being the chief expense. From £300 to £400 would cover the whole, and secure a good ventilation, with the furnace at hand that could be conveniently got to in all emergencies; and all the roads could be well sustained until the whole field of coal was exhausted.

But I must draw to a close, as it is impossible to enter into all the necessary details of working and ventilation in a single paper; but I would add, in conclusion, that if it is not possible to avoid explosions altogether, it is within the range of possibility to lessen the danger of explosion, and also the injurious effect of any explosion which may occur. These results cannot be accomplished without an ample and constant supply of air, a good plan for the distribution of the same through the entire workings, properly constructed furnaces, large heating surface, good dumb drifts, sufficient openings into the up-cast shaft, and shafts of sufficient capacity; trusty fire-men and furnace men, steady and vigilant discipline, and strict attention on the part of all in office; and when all combine to ensure safety, then, and only then, will success crown the efforts put forth. Then may the collier ply his calling in comparative safety, the proprietor invest his capital with confidence, and the products of the mines will, under an all-wise Providence, give a stimulus to trade, manufactures, railways, and navigation, and continue to raise this country of ours, commercially and socially, to a high place amongst the nations of the earth.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FIFTIETH MEETING, HELD IN ST. GEORGE'S HALL, BRADFORD, ON WEDNESDAY, DEC. 8TH, 1858, AT TWELVE O'CLOCK AT NOON.

Henry Brown, Esq., Mayor, occupied the Chair.

H. Brown, Esq., P. O'Callaghan, Esq., T. W. Stansfield, Esq., Mr. E. Milnes, Mr. George Knowles, Mr. John Woodhead (Eccleshill), and Mr. Samuel Baines (of Holroyd House, Lightcliffe), were elected Members of the Society.

The Mayor, in opening the proceedings, expressed his regret at the absence of the President of the Society. His unavoidable engagement on the grand jury at York prevented his being present on this occasion. He might say with regard to this Society that the meeting were glad to welcome it to the town on this occasion. He should have been glad to have seen the room quite full on that occasion, but in Bradford they were so deeply engaged in business that he supposed they could scarcely find time for entertainment of so interesting a character as that which was in store for the meeting. He could assure the active promoters of the Society, however, that the meeting gave to it a very cordial welcome to Bradford. Its objects were, of course, well known to the members, but to such as were unconnected with the Society, he might say, that its objects were, —1st, the investigation of the geology of the West Riding, with the accuracy and minuteness necessary for the successful prosecution of mining and agriculture; 2nd, the improvement of the arts of mining and metallurgy, and their dependent manufactures, and of the machinery and tools employed therein; and 3rd, the amelioration of the condition of the population connected therewith. The meeting would therefore concur with him, that in a large manufacturing and mining district like that of the West Riding, the objects which the Society had in view were of the highest importance. Indeed the operations of the Society hitherto had been of the greatest value in the prosecution of many of the most important branches of industry, especially in connection with mining operations. The Mayor concluded by again expressing his cordial welcome to the Society.

Mr. T. Wilson, in complimentary terms, moved that Viscount Goderich, M.P., be elected President of the Society, in the place of the late Earl Fitzwilliam, to whom he paid an affectionate tribute.

Mr. H. Briggs seconded the motion, and it was carried unanimously.

The following Papers were then read:—

ON THE ALLUVIAL LANDS, AND SUBMARINE FORESTS OF LINCOLNSHIRE. BY THE REV. EDWARD TROLLOPE, M.A., F.S.A., OF LEASINGHAM.

In every age the poet has been inspired to sing of fierce combats between man and man, whilst it has ever been the duty of the historian to narrate the rise, the progress, and the issue of those numerous contests carried on by nation against nation, ever since the world began. But it is a still grander subject that I would bring to-day before your notice, namely, a duel between two elements; and although I have neither the sweet strains of the poet, nor the exciting events of the historian to aid me, yet as I am possessed of some facts, certainly not generally known, resulting from personal observations of the substructure of an adjoining county, I am in hopes that a short digest of these may be acceptable.

A great contest between the sea and the land, leading to frequent changes in their respective boundaries, had certainly been raging upon the Lincolnshire coast for centuries before the arrival of the Romans in Britain, and that period when written records began to be kept. Doubtless the ocean has there, from time to time, swept far beyond its natural limits with an irresistible tide, reaching points in Lincolnshire now removed nearly twenty miles from it;* and yet, little by little, it has, through its very fury, aided to form a future barrier against itself. This it has done by the accumulation of the silt left upon its retreat, in concert with the earthy deposits caused by the continual flow of the inland waters, not only on either side of those points where they have respectively found an exit into the sea, but generally in that great bay of the Wash and its adjoining shores, reaching from Wainfleet to Hunstanton on the Norfolk coast, and so appropriately termed by Ptolemy "*Mentaris æstuarium*," or bay of river mouths. In this manner a considerable portion of the division of Holland has gradually been gained, or perhaps we may say, *re*-gained from the bed of the sea, whilst the continued growth of its coast, as well as of that of the southern part of Lindsey, is evinced by the relative position of the sea-banks that have been successively raised for its defence.

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* At Roxholme, near Sleaford, there exists a silty stratum abounding with cockle and other ordinary sea shells; and at Holbeach Hurn, at a distance of three miles from the sea, a seam of cockle shells, three inches thick, was traced by Doctor Latham two or three feet below the present surface. This was on land in the occupation of Mr. Baily, near Fleet Haven.

The subsoil of this district is Oxford clay, lying in waves, and once forming the surface. Over this has swept at some very remote period a vast and violent tide of waters from the N.W. to the S.E. portion of the county, which has left thick beds of drift behind it, consisting of white silty clay, boulders, large yellow water-worn flints, numerous beds of gravel, teeth and bones of elephants and various animals,* besides other deposits. Lincolnshire has, apparently, to thank Yorkshire for such a furious inroad. Through some convulsion or shrinking of nature a compound and chaotic marine flood has swept along the vale of York and the north-eastern portion of Lincolnshire, until, reaching that point of Cliff hills through which the Witham flows, at Lincoln, it burst over the whole tract of the lowlands of that county, and found an exit eventually in the sea. This will fully account for the layer of white silty clay often found above the Oxford clay, and filled with marine shells, as well as for the boulders and beds of gravel, &c., such as those near Lincoln, at Kyme, Tattershall, Edenham, Baston, and Deeping, &c. So far the sea had lorded it over a considerable portion of the Lincolnshire soil, but a rival now became predominant,—fresh-water was in the ascendant, and has plainly left the mark of its reign behind it in the form of a soapy blue clay, varying in tint and abounding with fresh-water shells. This is doubtless the deposit of sluggish streams and prevalent floods occasioned by the continual run of waters from the higher lands of the county before they were assisted on their way towards the sea by the hand of man; but the ocean was not tamed as yet, and we can see that it occasionally gave battle to the fresh-waters and their prey at this period by the existence of channels filled with marine silt running up into the blue clay in the form of bays and creeks. This stratum contained amply sufficient fertilizing matter for the sustenance of the finest trees of various kinds, and from it sprang up oaks of vast dimensions, lofty firs, alders, birch, and hazels, whose roots are still firmly fixed in the soil that originally so amply nourished them, whilst their innumerable trunks lie prostrate beneath a funeral pall of black peaty earth created by the debris of their own leaves mixed with decayed vegetable matter, such as stagnant waters always produce.

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* At Partney, a fossil tooth was found, weighing two pounds three ounces, in the gravel bed near Partney Mill, in 1822, twelve feet below the surface. It was supposed to have been one of the grinders of a hippopotamus or elephant.—Oldfield Addenda, p. 20. Another similar tooth was found at Quarrington, a few years ago, also in the gravel; and the skull of a cetacean, from the Lincolnshire fens, now in the Cambridge Museum, was supplied by the late Mr. Hopkinson, of Morton.

Occasionally, but more rarely, the sea still disturbed these vegetable cemeteries, for we find silty deposits in some portions of the fens of considerable thickness above the peaty stratum, and in a few instances alternating with it more than once.* How long the lands we are speaking of remained at a sufficiently high level above both fresh and sea waters to enable them to nourish trees of great size, including oaks varying from one foot to ten in diameter, is of course, uncertain, but from the last-named dimensions we may safely presume that this period of their growth lasted for five centuries. Again, how long these fen districts continued to be covered with stagnant fresh-water, after they had wrought such terrible ruin upon thousands of acres of the finest forest lands, is undeducible from any internal evidence, but they certainly were for the most part still prevalent, when a new and intelligent power drew near, already well practised in the art of combating with nature as well as with man, and that was the power of Rome. Probably the Romans were attracted to take possession of the rich Lincolnshire lowlands before the close of the first century, when they, no doubt, soon experienced considerable inconvenience from occasional irruptions of the sea, and from almost unceasing floods of fresh-water; but as they never submitted to such difficulties without a struggle, in which they were usually successful, they in this instance proceeded to encircle the whole coast of their new possession with a vast sea bank, capable of resisting all further encroachments of the sea,* and to deepen and defend the outfalls of its rivers. Next they began to gather up the valuable land they had by so much labour secured, and by the formation of a main drain, fifty-seven miles long, called the "Car Dyke," reaching from the Nen to the Witham, which caught all the waters flowing from the higher lands before they spread themselves over the lowlands, and by other drains, they completely secured for themselves the territorial fruits of their patient and enormous labours.

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* In Sutton, St. Edmund's Parish, two strata of peat are found, alternating with others of silty clay, two or three feet thick; also in Ramsey Fen, where, below the peaty surface and a clay substratum, a second deep deposit of peat exists.

But, besides the coastal line of fen lands, there are vast tracts in the interior of Lincolnshire of a similar character, forming together an aggregate of 522,000 acres, lying from four to sixteen feet below high water level. The largest of these extends from the Trent through the Isle of Axholme into Notts, and far into Yorkshire, in the direction of Doncaster; De la Pryme, in his Paper on Hatfield Chase, (Philosophical Transactions, No. 275, p. 980,) observing,—

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* It is interesting to observe how cleverly the Romans took advantage of all such assistance from the hand of nature as could be rendered available in aiding them to form this marine barrier, incorporating in their work, as they did, every sand bank or range of Dunes tossed up upon the shore by the united agency of tides and violent winds, so as to save labour. In Tetney parish, one of these banks, about three acres in extent, and fourteen feet high, has thus been made use of, (still bearing distinct evidences of having been occupied by the Britons,) in the form of five circles of earth, from one to two feet high, and from twenty-nine to thirty-eight feet in diameter; and on a similar adjoining bank, upwards of four acres in extent, and divided from the first by a little streamlet, is another circle, thirty-six feet in diameter; and a large oval one, sixty-five feet long, by forty-seven in width.

" That round about by the skirts of the Lincolnshire wolds unto Gainsburgh, Bawtry, Doncaster, Baln, Snaith, and Holden, are found infinite millions of the roots and bodies of trees, great and little, of most part of the sorts that this island either formerly did, or at present does produce, as firs, oaks, birch, beech, yew, winthorn, willow, ash, &c., the roots of all, or most of which stand in the soil in their natural postures, as thick as ever they could grow, as the bodies of most of them lie by their proper roots. Most of the great trees by all their length about a yard from their great roots (unto which they did most evidently belong, both by their situation and the sameness of the wood,) with their tops most commonly north-east, though the smaller trees lie almost every way cross those, some above, some under, a third part of all of which are firs, some of which have been found of thirty yards length and above, and have been sold to make masts and keels for ships. Oaks have been found twenty, thirty, and thirty-five yards long, yet wanting many yards at the small end." But perhaps the monarch of all these submerged trees was an oak, also alluded to by De la Pryme, which was fourteen yards in diameter, and forty yards long. This was calculated to have been not less than seventy yards high, and to have contained 1,080 feet of timber.*

From observations made in sinking a well in the Trent valley it was found that a stone causeway existed on a shingly gravel foundation, twenty-seven feet below the present level, above which were fragments of Roman pottery, &c.,

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* During the past year (1858) an oak has been extracted from Conington Fen, Hunts, sixty feet long to the collar, whence sprang two large limbs, each of which alone would have formed tolerably large sized trees, the diameter of the trunk was four feet. The level of Conington Fen has sunk five feet in consequence of its drainage, from which cause the above-mentioned tree was revealed. There the oaks alone are broken off from their roots, which remain embedded in the clayey subsoil, the elms, firs, and yews, having been uprooted when they fell and lie prostrate in all directions.

then a thick stratum of bog earth divided into two layers by a thin intervening stratum of sand, next foundations of buildings and bones of domestic animals, then bog earth again, and finally symptoms of modern cultivation. Hence it may fairly be assumed that during the Roman occupation of Britain, this vast tract of fen land bore quite a different character to what it has since done, that it had a gravelly subsoil* and an ordinary earthy surface covered with trees, not usually if at all subject to floods, but that subsequently it became, more or less, constantly submerged so as to destroy its previous forest growth, and to cover the bodies of the former vegetable giants of the district beneath one uniform dark surface—the offspring of a very inferior annual vegetable growth and decay, mingled with earthy deposits.

This great change has usually been attributed to the burning of the forests by the Romans, on account of the covert it afforded to swarms of suffering Britons, who lost no opportunity of harassing the forces of their subjugators on their march along the great military road, or Ermine Street, between Lindum and Danum; and there certainly are apparent signs of burning† about the stumps of some of these trees, but others have clearly been cut down, the marks of the axe still remaining perfect on their surfaces, and many more have been torn up by the roots, and occasionally splintered, perhaps by their fall. It is quite clear that the Britons and the Romans* used this great forest, traces of both having been discovered intermingled with its remains; and to them may be attributed the marks of cutting and burning still apparent. But great though the power of Rome was, and abundant her supply of British slave labour, I cannot think it possible that such an enormous tract of woodland, as Hatfield Chase, was destroyed by the hand of man, particularly as a clearance of a few miles on either side of their military way and around their various stations by the Romans, would have answered every purpose of security. No, I feel sure that a mightier power than that of Rome effected this revolution, namely, an operation of nature! The felled trees would never have so impeded the flow of the inland waters as to convert an immense district of previously dry land into a permanent swamp, as has been suggested. We will, therefore, endeavour to find another solution of this difficulty presently, in connection with a still more remarkable fact which remains to be brought forward, namely, the existence of a *submarine* forest off the present Lincolnshire coast.

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* In the valley of the Witham, at Lincoln, all the burials in the southern Roman cemetery are in the sandy subsoil of that locale, and the sepulchral monuments, &c., of that people are always found *below* the present superincumbent moorish soil.

† It is very observable (says De la Pryme) and manifestly evident, that many of those trees, of all sorts, have been burnt, but especially the fir trees, some quite through, and some all on a side, some have been found chopped and squared, some bored through, others half riven with great wooden wedges and stones in them, and broken axe heads, somewhat like sacrificing axes in shape, and all this in such places and at such depths as could never be opened from the destruction of this forest until the time of the drainage.

At intervals along the shore of that county, from Sutton to Clee-Thorpe, many banks or islands are from time to time exposed to view. These are usually covered with silt, but when occasionally stripped of that marine deposit, they are found to possess a substratum of moory vegetable soil, filled with the roots and prostrate trees of very large size, accompanied by their berries, nuts, and leaves. We will particularly instance some at Huttoft, in Calceworth Hundred, and marked in Mitchell's chart of this coast under the term of "Clay-huts," whence Huttoft perhaps derives its name. These were visited in 1796 by Sir Joseph Banks, and Corria de Serra, a scientific member of the Society of

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* Close to one of the roots of the submerged trees in Hatfield, eight or nine Roman coins were found, also much Roman pottery at other spots.

Antiquaries, who published an account of his observations on that occasion in the Philosophical Transactions of the Royal Society, whence we gather that these islands abounded with the roots of oaks, firs, and birches, still firmly imbedded in the soil where they grew, whilst their fallen trunks, covered with bark in a very fresh condition, were lying near them in the midst of a bed of partially decomposed leaves, mixed with decayed rushes, sedges, and other vegetable matter, forming a black peaty stratum; the water was observed to deepen on the seaward side of the line of islands, so as to form a steep bank, and the channels between them were from four to twelve feet deep. From experiments made below the surface of the islands, as well as at Sutton, Mablethorpe, and other spots on the mainland, it was clearly ascertained that the subsoil of both was identical.

It will now be my endeavour to answer the very natural questions that are sure to be put in connection with these facts, namely, "When these districts were severally submerged by fresh and salt water?" and "By what agency?"

Various theories have been advanced for the purpose of solving these problems, the principal of which are—

1. The interference of the Romans with the natural drainage.
2. A change in the coastal line through the action of the sea.
3. The agency of earthquakes causing subsidence of the earth.

Let us shortly consider each of these. There is no doubt but that the Romans did raise a continuous sea bank along the greater portion of the Lincolnshire coastal line, of which considerable remains still exist; also that they deepened the outfalls of rivers and such drains as they chose to make or retain, so that in after times, during the

Saxon period, should these have been neglected, as was most probably the case, the original evil would be greatly increased, because as the drainage of the whole lowland space within the sea bank was then dependent solely upon the artificial and not numerous outlets provided for them by the Romans, if these should be silted up, a permanent flood would be the consequence, bringing death and burial with its waters for the forests that once doubtless covered the fens of Lincolnshire, no tree being able to survive a continued immersion of its roots in water. This theory, however, respecting the subterranean forests of Holland and Kesteven, although very plausible, is not tenable, because it has been clearly ascertained that portions, at least, of the Roman bank are raised upon this very peaty stratum of which it has been supposed to be the originator,* so that the submersion of the forest land below, clearly belongs to a date anterior to the works above it; although from observations on the subsoil of Hatfield Chase, and portions of the Trent and Witham valleys, we have reason to suppose that a change of levels in those districts took place at a later period, Roman remains having been found there below the peat stratum very commonly, particularly when the enclosure of Austerfield was in progress.

Secondly, finding that the submersion of these forest lands was not affected by the agency of the Romans, also that large tracts of similar lands exist beyond the sea bank, and far below the usual level of the sea, it has been suggested that a change in the coastal line has been effected by the action of the sea.

Great changes have no doubt taken place in the outline of the Lincolnshire coast, owing to the action of the sea on its exterior, and the ceaseless flow of the inland waters from its interior. Many large estuaries are now completely filled up, which are known to have formerly existed;* whilst, from the remains of forests below the ordinary level of the sea, it is clear that the coastal boundary once extended far beyond its existing limits. To account for this last-named fact it has been supposed that a higher ridge of land may have once existed beyond the present tidal line, serving to protect a plain lying below the sea level, of which the islets still occasionally visible are a portion, and that this ridge was either gradually worn away by the continual action of the oceanic currents, which are remarkably strong off the Lincolnshire coast, or suddenly broken down by some extraordinary combination of wind and tide, upon which the low tract behind it would also of necessity become the prey of the ocean. It has also been suggested that as sandbanks off this shallow coast have been repeatedly known to disappear, and to form again on other spots with great rapidity in long lines parallel with the shore, a continuous barrier may have been thrown up under some extraordinary combination of wind and tide, behind whose sheltering limits vegetation might soon demonstrate its power, so as to gradually produce a forest that existed for some centuries, until at length that element from which it had been rescued, putting forth its whole strength, broke through the boundary of its own creation, and again claimed its supremacy over the tract beyond it. This theory is supposed to have been strengthened by the fact of the destruction in the 11th century, of a great part of Earl Godwin's lands on the Kentish coast, whose site is still so often and so fatally indicated by the Goodwin sands of Deal, and whose surface is exposed to view during low tides; but I believe both this Kentish submersion of land and that of Lincolnshire arose from another cause, which now remains to be considered, namely, "Subsidence." This phenomenon of the existence of submarine forests is by no means a rare one, and may be witnessed at various points of the shores of Scotland, England, and Wales. On the northern shore of Fife, bordering the estuary of the Tay, such a forest may be seen occasionally, although usually concealed by a bed of stratified silty clay, from fifteen to twenty-five feet thick, interspersed with marine shells. In Hartlepool Bay, such another forest may be seen during the lowest neap tides, whose stumps of oaks, firs, alders, thorns, and hazels, intermixed with their berries, nuts, seeds, and also with the horns of the ox, red-deer, and even with the wing-cases of land beetles, not unfrequently excite considerable attention. In this county are several similar instances. Off Outhorne is a bed of fresh-water deposit, usually below the sea, containing roots of oaks, hazels, &c., and amongst their fallen nuts and leaves, a British "dug-out," or canoe, was discovered, together with the horns and bones of the red-deer; and I am informed that at other points, on the Holderness coast, submarine forests have also occasionally become visible; also at Holme, in Norfolk, on the southern side of the Wash. The south coast possesses many examples of the same character, of which Bournemouth offers one, and the tract between St. Michael's Mount and Newlyn another. The latter was once no doubt forest land, and this appears to confirm in a remarkable manner, the ancient title of that extraordinary eminence, which, according to Carew, was termed "the rock in the wood." Sir H. de la Beche says the shores of West Somerset, Devonshire, and Cornwall abound with instances of these submerged lands; and one has come under my own notice during the past year in Padstow Harbour, on the northern coast of the last named county, which was suddenly exposed to view by the shifting of a sand bank. In South Wales, Giraldus de Barri, or Cambrensis, as he is usually termed, observed such a phenomenon so long ago as 1188. He says in his "Itinerary," chapter 13, page 217, "The sandy shores of South Wales being laid bare by the extraordinary violence of a storm, the surface of the earth which had been covered for many ages re-appeared, and discovered the trunks of trees cut off, standing in the very sea itself, the strokes of the hatchet appearing as if made only yesterday; the soil was very black, and the wood like ebony. By a wonderful revolution, the road for ships became impassable, and looked not like a shore, but like a grove, cut down perhaps at the time of the deluge, or not long after, but certainly in very remote times." In my opinion, however, these, and many other instances that might have been mentioned, of the present position of what have clearly once formed large forests districts, but are now far below the usual level of the sea, can only be satisfactorily accounted for by partial subsidences of the crust of the earth. This theory may indeed appear to be more marvellous than the preceding ones, and therefore less likely to be true in the opinion of those who are acquainted with geology; but when from the study of that science we find that certain strata, the undoubted deposit of water, are now upheaved far above the reach of that element, and that large tracts of land have sunk beneath it, we can only regard such changes as one of the usual, but always wonderful, operations of nature. Strabo was well acquainted with this motive power in the earth's crust, who says, "It is not because the lands covered by seas were originally at different altitudes that the waters have risen or subsided, or receded from some parts and inundated others; but the reason is that the land is sometimes raised up, and sometimes depressed, and the sea also is simultaneously raised and depressed, so that it either overflows or returns into its own place again." It may be said, however, these were old—perhaps antidiluvian changes, and we are quite sure the earth has long stood firm. It will be well, therefore, to mention an instance of the subsidence and elevation of land during the historic period. Perhaps the most noted one is that which occurred at Pozzuoli, in the bay of Baiæ, as indicated by the pillars of the temple of Jupiter Serapis at that place, and certified by documentary evidence. Originally, that temple of course was built above the level of the sea; the site then sank twelve feet, so as to submerge its columns in a fresh-water deposit which protected them from future injury. The subsidence, however, continued, and then the sea swept over this newly-formed marshy surface, covering the columns of Jupiter's temple to a depth of nine feet more, and exposing them to the depredations of that destructive marine bivalve, the "Lithodomus" of Cuvier, from which they have greatly suffered. At one period then they were sunk twenty-one feet below the sea level,* leaving a little less than half of their original height above it; but then another change began, and the flat shore where this temple stands gradually rose again; a document of the reign of Ferdinand and Isabella of Spain, referring to a grant of land at Pozzuoli made to the University of that town "where the sea is drying up," and another of Ferdinand's alone, a little later, speaking of the same locale as one "where the ground was dried up." In the year 1538, the year of a great eruption of Vesuvius, the land about Pozzuoli rose rapidly, but it has since slightly sunk again, and now is apparently stationary. Again, an earthquake that occurred in 1819, on the delta of the Indus, was followed by very extraordinary and permanent changes in the levels of the adjacent district; the eastern channel of that river bounding the province of Cutch, suddenly deepening at Luckput from one foot to eighteen feet, so as to render it navigable, and at the same time creating a large inland lake, whilst Sindree, above Luckput, together with its fort, gradually sank below the newly-created waters, until its angle towers alone appeared above their surface; but in exchange for this depression, an elevation fifty miles long appeared rising from a previously flat plain, at a distance of about five miles from Sindree, which the inhabitants very appropriately termed "Ullah Bund," or mound of God. Perhaps, however, the most striking modern illustration of what has once taken place in many portions of England, may at this time be witnessed in the United States. In 1811, the valley reaching from the mouth of the Ohio, to that of the St. Francis (300 miles long), was convulsed, after which several new lakes were formed, such as Obion in Tenessee, twenty miles in length, and another near New Madrid, about ten miles west of the Mississippi in Missouri, termed "the sunk country." This is seventy or eighty miles long, and thirty wide, and from its placid surface rise the trunks of innumerable semi-submerged trees, all dead, and whitening in the wind previous to the final plunge they must all shortly make into that deadly element below, wherein so many of their brothers have already sunk before them.

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* Farming of Lincolnshire, by John Algernon Clarke, Agricultural Journal, vol. 12.

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* Such as Bicker Haven, seven miles long, which still remained a salt marsh in 1611, being marked as such, at that date, by Hondius, on a map of the lowlands of Lincolnshire, &c., he published at Amsterdam, and which must have entirely altered the outline of the Wash.

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* Evidence of a most conclusive character was obtained by Mr. Babbage, as to the elevation of a considerable tract of land in the vicinity of this temple, at thirty-two feet above the present sea level, he having discovered a wave-worn line covered with barnacles, and pierced by boring testacea on the face of the banks above the tract of land lying below them.

It may be remarked, however, that in these instances, volcanic agency was the cause of the subsidences spoken of, whereas no signs of such a power exist in the lowlands of Lincolnshire or on its coast. But neither are they to be found in that of the American sunk country, nor do earthquakes usually leave any direct evidences of their mighty agency behind them, although they often have been connected with permanent changes of the earth's surface of a great and extraordinary character. Again, even some natives of Lincolnshire may say "But when had we earthquakes?" I will therefore instance a few. In 1048 there was a serious convulsion in that county,* also another in 1117, that particularly affected the division of Holland, greatly endangering and injuring Croyland Abbey, portions of which, then just built, were with difficulty stayed up by vast timber props.† In 1185 Lincoln was much damaged by an earthquake.‡ In 1448 a violent shock was again felt in the southern parts of the county.‖ In 1750 a shock occurred throughout its whole extent, and in parts of Lincolnshire and Northamptonshire, attended by a rumbling noise. It happened on a Sunday and the people ran out of churches from their devotions in great alarm; chimneys fell, houses tottered, and plates, &c., fell from shelves§ And so late as 1792, Bourne and the neighbouring towns experienced another shock of an earthquake. It is not necessary to point to any instances of elevation of land in Lincolnshire as a counterpoise to the subsidence of others for the purpose of corroborating this theory which I have ventured to advance, because none was observable in the case of the Mississippi valley and other examples, but I am inclined to think that a slow upward movement has begun to take place in large districts of Lincolnshire long ago, and that by means of carefully conducted scientific observations this will be hereafter certainly proved, and accurately measured. The filling up of channels and estuaries of large size that formerly existed, and the rapid growth of its coasts at various points, apparently indicate this, whilst the known gradual but continually increasing elevation of the Danish Coast, and parts of Norway, greatly strengthen such a supposition.* Nor need such a hypothesis be considered extravagant. There stands the fact of the existence of submarine forests. They must have acquired their present position through some convulsion of nature, that I believe to be subsidence, and surely the upheaval of lands is not more extraordinary than their depression; at all events both phenomena have repeatedly occurred on a very large scale; and, in conclusion, I thankfully shelter my opinion behind the strong shield of Sir Charles Lyell, who says (Principles of Geology, page 289,) "If we could compare with equal accuracy the ancient and actual state of all the islands and continents, we should probably discover that millions of our race are now supported by lands situated where deep seas prevailed in earlier ages. In many districts not yet occupied by man, land animals and forests now abound, where ships once sailed; and on the other hand we shall find on inquiry, that inroads of the ocean have been no less considerable. When, to these revolutions produced by aqueous causes, we add analogous changes wrought by igneous agency, we shall perhaps acknowledge the justice of the conclusion of Aristotle, who declared (Meteorics, chapter 12,) "That the whole land and sea on our globe periodically changed places."

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* 1048. Quo anno terræmotus factus est magnus Cal. Martii die Dominica.—Historia Ingulphi, (Oxford edition, 1684) p. 64.

† Hoc terræmotu cum etiam Anglia in multis provinciis gravissime vexaretur, verum Ecclesiæ Croylandensis opus recens, et adhuc sine constabiliente nave tenerum, proh dolor! in australi muro corporis sui horribilibus orificiis dehiscens, proximam ruinam minabatur acturum, nisi Carpentariorum industria longissimis trabibus and tignis transversis stabili concordia, usque ad navis impositæ confœderatioriem deinceps solida constantia fulciretur.—Ibid, p. 129. Petri Blesensis continuatio.

‡ A.D. 1185. Terræ motus magnus auditus est fere per totam Angliam, qualis ab initio mundi in terra illa non erat auditus. Petræ enim scissæ sunt, domus lapideæ ceciderunt, Ecclesia Lincolniensis metropolitana scissa est a summo deorsum. Contigit autem terræ motus iste in crastino diei dominicæ in ramis palmarum, viz. xvii Kal. Maii.—Roger Hoveden, 359.

‖ Historia Croylandensi continuatio, p. 526.

§ Collections for a Topographical History of the Hundred of Aveland, by John Moore.

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* Professor Worsaae, in his Primæval Antiquities of Denmark, page 9, says,—"Denmark seems to have been raised, by a powerful revolution of nature, from the bottom of the sea. By degrees its naked banks of gravel became covered with aspen forests. When the land rose still higher, and the dampness diminished, the aspen disappeared after having, by numerous growths, formed a way for the fir, which now spread all over the country. This species of tree continued for a very long period, but at length was compelled to give place to a very different and a higher class. At first the beech was unable to grow here. The earth was covered with oaks, of that species termed the winter oak, which differs from the now prevailing species, the summer oak; these were succeeded by groves of alders, until all was so prepared and developed that the light and beautiful beech spread its crowns over the whole country. That Denmark in its primæval times, before it possessed its present vegetation, had passed through these four periods, is clearly proved from the ancient peat bogs, in which are found stems of trees of each distinct period lying like beds one over the other."

NOTICE OF THE DISCOVERY OF A BRITISH DAGGER FOUND AT WOODNOOK, NEAR WAKEFIELD.

T. Wilson, Esq., Vice-President of the Society, read a "Notice of the discovery of an ancient British Dagger at Woodnook, near Wakefield." The dagger was found in the year 1842, in the valley of the Calder, about five miles north-east of Wakefield, in the township of Altofts. Not far from the point where the Midland Railway crosses the river Calder, and on the west side, may be seen a lock, by which the new line of navigation re-enters the river. While the workmen were excavating this lock, at a depth of twenty-four feet from the surface, they came to the shale which forms the upper portion of the original rock of the district. Over this they had passed through alluvial matter; the alternations of which the author described. A section of the spot gives the following:—

Soil	24 feet.
Sand	
Gravel	
Silt and Sand with Black Oak	
Red Gravel	
Black Bind	

The circumstances detailed imparted to the relic a geological, as well as an antiquarian interest. It was found lying flat, and covered by a layer of sand, in which there were pieces of black oak, lying right above it, precluding the notion that it could have sunk into that position, and indicating rather that the whole of the alluvial matter found above it must have been deposited since. It is of a beautiful yellowish bronze colour; and its elegant form and workmanship indicate a very high state of the arts necessary to the manufacture of weapons of this kind. Three rivets, by which it was attached to the handle, still remain. The interest that attaches to this relic is enhanced by the fact that, in the year 1818, at Stanley Ferry, a few miles above the place where it was found, the remains of a canoe formed from the solid oak, also of this period, were discovered. It was similarly embedded in the detritus of the country, and was eighteen feet six inches below the present surface of the ground, and about six feet below the bed of the river, and measured in length seventeen feet nine inches, and its greatest breadth is three feet ten inches. A number of oak trees, quite sound and black, were found near to the canoe, which is now deposited in the museum of the Yorkshire Philosophical and Literary Society, at York.

Mr. Briggs inquired whether the spot where the dagger was found was not very near to the hill called Fairies Hill?

Mr. Wilson said it was a very short distance from the hill.

Mr. Briggs remarked that the origin of the Fairies Hill was no doubt artificial. The question was, by whom was it formed? It was generally supposed to have been formed by the Romans, for at Castleford, distant about three-quarters of a mile, there was a Roman encampment, and it was thought that this hill was a sort of outpost of that encampment. In forming a dock within three hundred yards of the place where this dagger was found, the workmen came to two large logs of oak. They were put across, as if to dam up the water and make a fosse round the Fairies Hill; they were about twenty feet below the surface, perfectly sound, and quite black.

Mr. Jebson asked if the dagger had been minutely examined to see whether there was any inscription upon it?

Mr. Wilson said it had not been examined by a powerful magnifier that he was aware of. There were some marks, but he thought it would be difficult to say that they were anything more than accidental scratches, except the ornamentation.

The Rev. Mr. Trollope said he had paid particular attention to articles of this sort, and he was quite satisfied, without examining the dagger now exhibited with a magnifying glass, that it had no letters upon it. They occasionally found Runic inscriptions, but the punctures upon this dagger were simply ornamentation, certainly not letters. The question of—Who made this weapon? was well worthy of consideration, and particularly so as it was not an easy one to answer. He believed, and he was strengthened in that belief by the best authorities in England, that these daggers, of which they had there a specimen, belonged to the same period as the leaf saws, also made of the same metal, and it was not positively pretended by any authority to what nation they belonged; but they believed they were justified in saying that they belonged to nations long prior to the time of the first Roman invasion in this country.

Mr. O'Callaghan also took part in the discussion, and mentioned the curious and amusing circumstance that four brass plates, which were deposited in the museum at Florence in the fifteenth century, had remained there until 1848 without anybody knowing to what nation they belonged, when a gentleman who visited the museum found, from the inscriptions upon the plates, that they were advertisements, in Irish, of a skipper wanting a cargo to go to the Western Islands. They were placards put up to encourage emigration to those islands.

The Rev. Mr. TROLLOPE remarked that in his own county (Lincolnshire) a large bone comb was found in a case, with a good deal of ornamentation upon it. There was also an inscription, in Danish, to this effect—" Tastig makes a good comb." That was the only instance he knew of in England of a Danish inscription being found upon a Danish comb. He mentioned this to show that it was well worth while examining, with a magnifying glass, articles of this kind, to see whether there was any inscription.

The Rev. J. H. RYLAND remarked that the " Dagger" appeared to him like a spear head, and it looked very modern.

ON THE LEAD MINING DISTRICTS OF YORKSHIRE. BY STEPHEN EDDY, ESQ., OF CARLETON GRANGE, SKIPTON.

(Abstract of a Paper read before the British Association, at Leeds, 1858, and published in their Report.)

In comparison with the vast coal-fields and ironstone beds of Yorkshire, the lead producing districts of this county seem trifling; yet, in consideration of the large population dependent upon the mining and manufacture of lead, they necessarily claim our attention.

That lead mines in Yorkshire were prosecuted by the Romans, is fully proved by the discovery of two pigs of lead near Pateley Bridge, inscribed with the name of the Emperor Domitian, and bearing date A.D. 82; but it is very probable that they were worked at even a more remote period by the ancient Britons. Generally speaking, lead mines are situate on rugged and barren elevations; and in this respect the Yorkshire mines are not exceptions. If on the map we measure ten miles east and ten west from Ilkley, on a line bearing 12° north of east and south of west; and at right angles to this base, draw lines northward thirty-five miles from the two points so obtained, we shall, in this area of 700 square miles, include the high grounds bounding Airedale, Wharfedale, Nidderdale, Wensleydale, Arkendale, and Swaledale, in which the principal lead mining fields of Yorkshire are situate. The strata throughout this area, are the lower members of the carboniferous series. Though the same class of rock prevails throughout the lead bearing districts, each individual stratum does not always occur in neighbouring mines, while the thickness of each bed is exceedingly variable.

In the metalliferous portion of the carboniferous rocks, we have the rake vein, the pipe or tube vein, and the lateral-embedded or flat vein. The first appearing as a rent or fissure through the strata, of a great length, and generally to an unknown depth. The pipe vein has the form of an irregular cylindrical tube, is met with in certain strata, (generally limestone), and dips with the beds, or passes more or less diagonally through them for a great length. The third, or flat vein, is seldom met with except in connection with a rake vein, but has always a position conformable to the stratum in which it is embedded. Rake veins are by far the most numerous in every district, and their phenomena the most varied and complicated. The greater portion of our lead ore is likewise from them. The "bearing" of a rake vein is seldom a perfectly straight line, but generally approximates thereto in its entire length. The "hade" or inclination varies considerably in the angle formed with the vertical. It is likewise more horizontal in the soft or argillaceous beds, than in the hard and solid rocks; while, frequently, in passing a thin seam of coal, or of soft clay, it flats away with the stratum for a greater or less distance. The width of a vein is far from uniform; frequently opening from a foot or two wide to as many yards, and then contracting to a mere joint. The width varies also with change of strata; it is much greater in the hard strata than in the soft; it is, generally, more open in limestone than gritstone, and much contracted in the plate or shale. Frequently the vein is found four or five feet wide in the limestone and gritstone, when it is scarcely perceptible in the plate. Where the longitudinal extremities of a vein have been explored (which is very seldom done), the lode is found to split into numerous branches, which quickly terminate. This ramification of the lode is often anticipated, from the introduction into the "bearing" beds of accidental shales. Rake veins are generally fault veins. As a rule, the strata are lower on that side to which a vein hades or inclines, called the "hanging wall," than on the one upon which it rests, known as the "foot wall."

The extent of throw varies from a few inches to twenty or thirty fathoms; this extreme throw being often met with when veins are in the immediate vicinity of each other. The "strength" of a vein is considered to be in direct proportion to the extent of fault or throw; but a vein with a difference of from six to eighteen feet is regarded with more favour by the miner, than one with a greater or less throw: such a fault being indicative of sufficient strength of vein to ensure its continuity at a moderate size, but not such as to destroy the effect supposed to be produced by certain beds when in the same horizontal line on each side of the vein.

When rocks, differing in their character and composition, form the opposing sides or cheeks of the vein, we do not often expect to find a deposit of lead ore. There are, however, exceptions to this rule. At the Grassington mines, in Wharfedale, are two veins, each throwing the south side down to such an extent as to cause plate to be opposed to gritstone, plate to limestone, and gritstone to limestone, and so on throughout the whole depth explored on them. Thus circumstanced, one of these veins yielded great quantities of ore, whilst its neighbour proved totally barren.

Generally, when a vein occasions a throw of two or three fathoms, the ore neither continues above nor below the change of strata, but is confined to that part of the vein bounded by the bearing rock. This, however, has an exception in a vein at the mines before mentioned, which is at present producing large quantities of galena. In addition to affecting the fault or throw, rake veins, likewise, in most cases act "locally" on the "dip" of the strata, gradually bending the planes of stratification of the elevated beds, (for a short distance from the vein), downwards; while in like manner they draw those of the depressed strata upwards.

In each of our lead bearing districts the strata consist of numerous alternating beds of plate, grit, and limestone, forming the Yoredale rocks of Professor Phillips. Though the veins are found to traverse all these beds, it is only (generally speaking), in certain ones that lead ores are found; limestone being the prevalently productive strata in some districts; while in others the principal yield is from the gritstone. The argillaceous plates seldom produce ore, but even this admits of exception; and the Cononley mine, in Airedale, (where the alternations of thick plates with their gritstones are exceedingly numerous,) has yielded continuous bunches of ore from the surface to a depth of thirty fathoms. From these facts it will be noted, that in mining for metallic minerals in this formation, we are not justified in the application of any but general rules; and that these admit of great variation in each district.

Many veins, particularly in our more northern fields, have a tolerably direct course for a considerable distance. The Old Gang vein, in Swaledale, has been worked for many miles in length, and can be traced to a much greater distance in nearly a straight line.

In the three northern fields, viz. :—Swaledale, Arkendale, and Wensleydale, the veins are more regular in size, and the beds of a more uniform thickness, than in the three southern ones. In the former, the calcareous beds have been the principal sources of produce, while our southern mines have their principal deposit in the gritstone. There are many other peculiarities which strongly distinguish the veins and beds of our northern dales from those of the southern; and we may accept this natural division of the Yorkshire mines into two great classes, as sufficiently defined for our present purpose. The rake, the pipe, and the flat vein, appertain to each district. Ores from the pipe and flat veins are much more fusible than from the rake; and the ores from the limestone beds are in like manner preferable to those from the gritstone.

It has been asserted that Slickensides has never been found in the gritstone. The specimen now produced proves the fallibility of this conclusion; being obtained from the "grit" in the Grassington mines, where it was found, forming the only division between two veins for about seventy yards in length.

The major part of veins in each district are nearly parallel to each other, while the remainder run counter to, and form intersections with them. The predominant direction in the northern district is north of east, and south of west; while in the southern fields it is north of west, and south of east. The former, or "right running veins," when intersected by the counter or oblique veins, are frequently heaved or thrown from their course, and often otherwise affected. The heave or throw is generally found to be on the side of the oblique angle, formed by the intersecting planes of the converging veins. Cases to the contrary have, however, occurred, and at the Grassington mines one exception to the rule took place, where the vein was heaved to the acute angle, and lengthened about fifty yards. This dislocation of veins is indicative of different periods of vein-formation. When one or both veins produce ore up to the point at which they meet, the yield is mostly increased by their junction. The extent of the angle formed by the two veins is, however, in the miner's mind, indicative of the result—the more acute the angle, the greater the chance of a deposit.

The greater portion of the produce of the northern district is from the Old Gang Mine in Arkendale, and Kell Head in Swaledale; while the Grassington Mines, in Wharfedale, yield about two-thirds of the produce from the southern fields.

From what has been briefly advanced, it will be noted, that mining for metallic minerals is of a much more uncertain and speculative character than that for coal; and further, that lead mining in stratified districts is attended with greater difficulties and uncertainties than in the more Primitive rocks. It must not be supposed that in any lead mining district the veins are continually productive; since the best bearing lodes have often great lengths of unproductive ground. In all mining districts, especially in a stratified country, the phenomena presented by veins, their frequent heaves and dislocations, and their varied appearances when bounded by different rocks, call for very close attention; and even a dependence on knowledge acquired in one district may prove fatal in another. The miner should be perfectly acquainted with the nature of those substances which it is his daily task to seek in the bowels of the earth; as well as with those which, though perhaps worthless in themselves, generally indicate the presence or absence of the immediate objects of his search. Long and practical experience, aided by a knowledge of geology and mineralogy, can alone furnish him with this requisition, and is therefore essential to success.

ON THE YORKSHIRE FLAGSTONES AND THEIR FOSSILS. BY SAMUEL BAINES, ESQ., OF HOLROYD HOUSE, LIGHTCLIFFE, NEAR HALIFAX.

My observations are intended to simplify a formation found in the vale of the Calder and its tributaries, in the eastern part of the parish of Halifax, distributed over the townships of Shelf, North and Southowram, Rastrick, and Hipperholme-cum-Brighouse—a district which, I fear, has been much neglected by geologists. About the year 1831, the time of the first meeting of the British Association in York, the prevailing opinion in the district coincided with Dean Cockburn, that all fossils were created as they are found; or, if changed, only by diluvial action; or that the myriads of impressions on our shale were freaks of nature, similar to the crystallisation seen on windows in frost. It was a very simple formation of what is termed the freestone that first struck me how regularly and slowly this strata was deposited, and suggested the idea that all the different strata of sedimentary rocks were formed in a like manner. On a bleak moor side, in the shelving formation of a fine sandstone, was a hollow dammed across for the accumulation of rain water for scouring purposes. In a few years it was filled up by a gradual deposit of sand. When dug out, it was a fine laminated strata. In noticing other depositions, I found that each layer was the deposit of one shower, and in proportion to the quantity or time of each succeeding rain did the thickness of the deposit depend; each layer is one flood, a time intervening when the sand was all accumulated at the bottom, and the water had smoothed its surface by a very gentle action, so that the smoothed bed would not allow of the next flood's deposit to mix, hence the sure illustration of the much-vexed question of cleavage where heat or oblique pressure have not disturbed the original deposition. It may be as thin as paper, or one inch thick for roofing slate, or two or three inches thick (which is the Yorkshire flag), or an uninterrupted deposition of ages, when it becomes the cutting stone or ashlar, a number of square yards in one mass without any cleavage. It is, perhaps, not all speculation to say, that this Yorkshire flag is but the pond on a larger scale, and the deposition of some ancient estuary, whose waters washed the finer particles of the carboniferous sandstone from the Halifax and Todmorden districts; but the deposition must have taken place, if not in deep water, certainly in still water, for the smallest, yea, the faintest breeze of wind caused the ripple-marks, as thousands of the freestone show, in the strata overlying the flag formation, and one strata must have been formed in shallow water, and at times completely dry, as there are hundreds of acres which bear impressions of rain, or hail drops having impinged upon the strata, in process of formation. There are great quantities of the tracks and depositions of a species of annelide, or, as we locally term them, the earthworm. We have this deposition taking place from the annelides even now. It is a formation extremely barren of animal remains; the quarrymen adhere doggedly to the opinion of a live toad being found occasionally entombed in the rock. I have not yet myself seen sufficient evidence, but I do know that a quantity of large bones were dug from a quarry in Southowram and sold to an old bone collector for a quart of ale. Since that time, there has been a better look-out for fossil remains, and the impressions of something like a large foot have been found, which suggested the idea that it was the foot-prints of the same animal whose bones were exhumed within a few yards. The flora in the Yorkshire flag is not so numerous as in the crooked stone below and above, simply from its being a quieter deposit than the other strata. The most common fossil found in this formation and its kindred shale is the Calamite, a species of water plant, reed, cane, or rush; some shales between the different strata being literally composed of its impressions. The next most common plant is the stigmaria, and if it be the root of the sigillaria, as some paleontologists affirm, and I have no doubt of it—we have them in profuse abundance, but very rarely the trunk of the sigillaria. It is quite evident that the tuberous appendages denote it to be a mud plant or root. There are some of the most magnificent and perfect specimens of the lepidodendron found in this strata. There are also pecopteris nervosa and neuropteris, &c., as also a few fossil fruits, similar to trigonocarpum ovatum, hazel nuts, &c. This formation, with its fossil plants, may strictly be termed a mud formation; hence the idea with many that it is a modern formation. But from the specimens named, it would appear that they are similar to the Newcastle coal field fossils, figured in Lindley's and Hutton's Fossil Flora, and for which strata I claim a similar age. We have only two seams of coal, namely, the Halifax soft and hard beds, under this strata, before the great Sandstone Grit Base, or back-bone of England comes on, while we have thirty-three beds or bands of coal, with hundreds of varying strata overlying this deposit, within twenty miles eastward, at Old Normanton, forming a series over seven hundred yards deep. This freestone deposit must have taken place before the beautiful valley of the Calder and its many kindred valleys were worn by the advancing and receding tides of some primæval ocean. The tributaries have only their own local sandstone boulders, while the main valley of the Calder has almost every variety of boulders, from granite, mountain lime, to sandstone, &c. Any thoughtful observer, looking from some elevated point up the valley, cannot but be struck with the numerous bold promontories whose more compact rocks have withstood the wild dash of the ocean's wave, the varying temperature of the active atmosphere, the thundering boulders, and the glacier beds.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

Of the West Riding of Yorkshire,

AT THE FIFTY-FIRST (THE ANNUAL GENERAL) MEETING, HELD
IN THE PHILOSOPHICAL HALL, LEEDS, ON THURSDAY, MARCH 17TH, 1859,
AT TWELVE O'CLOCK AT NOON.

JOHN HOPE SHAW, Esq., in the Chair.

The CHAIRMAN in opening the proceedings expressed his regret that there were not more present, but remarked that the Society must not be judged merely by those attending its annual meetings, as it exercised a very important influence by means of its published transactions. He suggested, however, whether it would not be better in future to hold their meetings in the evening, after which he alluded to the union of the Yorkshire Philosophical and Scientific Societies, as proposed during the meeting of the British Association in Leeds, expressing the hope that, though such a union was postponed for the present, it would hereafter be realised, believing it would be for the benefit of their members and of science generally.

Mr. Denny read the following financial statement for the past year :—

STATEMENT OF RECEIPTS AND EXPENDITURE

OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST RIDING OF YORKSHIRE.

From January 28th, 1858, to March 17th, 1859.

DR.	£.	s.	d.
By Balance in Treasurer's hands....	0	17	8
,, Subscriptions—			
From 1 Member for 1855	0	13	0
,, 2 ,, 1856	1	6	0
,, 23 ,, 1857	14	19	0
,, 84 ,, 1858	54	12	0
,, 2 ,, 1859	1	6	0
	£73	13	8

CR.	£.	s.	d.
To Collecting Subscriptions	1	7	4
,, Postages	1	16	4
,, Philosophical Society, for Rent of Museum	23	10	0
,, Messrs. Baines, on account......	21	2	0
,, Advertising Meetings	1	10	0
,, Expenses of Meetings	2	11	6
,, Assistant Secretary, on account	21	0	6
,, Sundries, Stationery, &c.........	0	16	0
	£73	13	8

LIABILITIES.	£.	s.	d.
Messrs. Baines, for Printing	24	5	0
Assistant Secretary	20	7	0
Palæontographical Society	1	1	0
	£45	13	0

ASSETS.	£.	s.	d.
Arrears of Subscriptions	24	5	0
	£24	5	0

The following Officers and Council were elected for the ensuing year :—

President.

THE EARL OF RIPON.

Vice-Presidents.

The Duke of Norfolk.
The Duke of Leeds.
The Earl of Effingham.
The Earl of Dartmouth.
Earl Fitzwilliam.
Lord Londesborough.
Lord Wharncliffe.
Viscount Galway.
Rt. Hon. Sir C. Wood, Bart., M.P.
Edward Akroyd, Esq.
John Waterhouse, Esq., F.R.S.
T. W. Beaumont, Esq.
E. B. Denison, Esq.
William Beckett, Esq.
R. M. Milnes, Esq., M.P.
J. Spencer Stanhope, Esq.
Godfrey Wentworth, Esq.
J. G. Marshall, Esq., F.G.S.
Michael Ellison, Esq.
Rev. William Thorp, M.A.
Thomas Wilson, Esq., M.A.

Council.

Henry Briggs, Esq.
Dr. William Alexander.
H. C. Sorby, Esq., F.R.S.
Henry Holt, Esq.
Bentley Shaw, Esq.
T. P. Teale, Esq., F.L.S.
Richard Carter, Esq.
Thomas W. Embleton, Esq.
J. H. Shaw, Esq.
Dr. Scholefield.
E. W. Shaw, Esq.
H. Brown, Esq.

Honorary-Secretary.

William Sykes Ward, Esq., F.C.S.

Honorary-Curators.

J. G. Marshall, Esq.
T. W. Embleton, Esq.

Local-Secretaries.

Sheffield—H. C. Sorby, Esq.
Wakefield—Henry Briggs, Esq.
Halifax—Dr. W. Alexander.
Doncaster—Dr. Scholefield.
Huddersfield—B. Shaw, Esq.
Barnsley—R. Carter, Esq., C.E.

The following Papers were then read:—

ON THE STRUCTURE AND ORIGIN OF THE MILLSTONE-GRIT IN SOUTH YORKSHIRE. BY H. C. SORBY, ESQ., F.R.S., F.G.S., &C.

The nature of the materials of which stratified rocks are composed is not only interesting on its own account, but especially so as enabling us to form some opinion on the geological characters of the ancient land from the waste of which the materials were derived. It is for this reason in particular that I now purpose giving a short description of some facts I have ascertained with respect to the millstone-grit in South Yorkshire. In many places this rock is a very coarse-grained sandstone, being often made up of grains ranging up to $\frac{1}{10}$th of an inch in diameter, along with which are rounded pebbles, whose size varies up to fully one inch in diameter.

In order to ascertain the laws governing the drifting forward of sand and pebbles along the bottom by a current of water, and those involved in their final deposition, I made a number of experiments some years ago, which I briefly described in a paper read before the British Association at Glasgow, in 1855. I there showed that, if there be a surface of moderately coarse sand, like that composing the millstone-grit, rounded pebbles do not sink into it; and that the resistance they experience in moving over its surface is no greater in proportion to the motive power of the current than in the case of grains of sand; and, therefore, a current moving with sufficient velocity to drift forward coarse sand, would be sufficiently powerful to carry forward a few rounded pebbles, by rolling them over the irregular surface of the sand, but not sufficiently powerful to transport them over the much more irregular surface of a deposit consisting altogether of similar pebbles. On the contrary, when the surface at the bottom is composed of very fine sand, pebbles, whose size in proportion to that of the grains of sand is the same as in the case of the coarse sand just described, sink so deeply into it that a greater force would be requisite to move them forward; whilst at the same time the motive force of the current is reduced by a smaller proportional part of their surface being exposed to its action. On this account a current just capable of drifting forward the very fine sand, could not transport the pebbles over its surface; whereas, if the current were strong enough to wash along the pebbles it would be too strong to permit the sand to be finally accumulated along with them, when anything occurred to reduce its velocity. These principles completely explain why pebbles do not occur in the fine-grained beds, but are very constantly met with in the coarse-grained; whilst at the same time they are seldom found as separate beds without sand.

Very much of the millstone-grit is made up of that kind of oblique false bedding for which I have adopted the term *drift-bedding*, as described in my various papers in the Edinburgh New Philosophical Journal, (new series, vols. iii., p. 112; iv., p. 317; v., p. 275; vii., p. 226;) and also in the Reports of this Society, (1852, p. 232, and 1854, p. 372.) My experiments show that, when pebbles mixed with sand are carried forward by the current, and arrive at the part where they are thrown down on a slope, so as to form a bed of this drift-bedding, the pebbles usually roll to the bottom of the slope, whilst the sand rests higher up; and thus a bed of sand is formed, having oblique stratula and a band of pebbles along the bottom.

A superficial observer, not aware of the peculiarities in the laws governing the transport and acccumulation of sand and pebbles, might be led to think that such a band of pebbles was a separate bed, formed by the action of a more powerful current, and that the sand was afterwards deposited over it, but in very many cases the above is certainly the true explanation. Although the larger rounded pebbles have a great tendency to roll to the bottom of the slope, some of more irregular form or those accidentally entangled in the sand have sometimes remained higher up, scattered amongst the sand, yet often in bands, probably indicating some variation in the velocity of the current. All these peculiarities in the arrangement of the materials had been explained by my experiments on the angles of rest of various deposits, but since then I have been able to still further prove the truth of my deductions by means of my machine for producing drift-bedding artificially, described at the meeting of the British Association at Cheltenham, (Report for 1856, p. 77); and in my Paper on the Tertiary Estuary of the Isle of Wight, (Ed. New Phil. Jour., n.s., vol. v., p. 280). If coarse emery be mixed with fine white sand, it is arranged along with the sand, when they are deposited by the action of the machine precisely in the manner I have described; the artificially prepared deposit being in all respects analogous to the naturally formed millstone-grit, the resemblance being so close that I was even led to perceive some very important peculiarities in the natural rock by examining what took place in the formation of the artificial deposit.

By far the greater part of the pebbles in the millstone-grit in South Yorkshire are of white quartz, but only a very moderate amount of examination will enable any one to see that pebbles of felspar are not at all uncommon. These are now often very much decomposed, though some are not, but are semi-transparent and have a clear sharp cleavage. If the sandstone itself be carefully examined, it may be seen that it is composed of the self-same materials as the pebbles, in a finer state of division; but the felspar is usually more completely decomposed, and fills up the spaces amongst the grains of quartz sand. It therefore appears as if the rock had been originally formed from a mixture of quartz sand and felspar sand, but, after deposition, the felspar having been decomposed into a clay-like material, has been forced by the pressure of the superincumbent rocks into the spaces between the grains of quartz sand; which change would, of course, reduce the bulk of the deposit. This fact affords a most satisfactory explanation of what at first appeared to be a very anomalous circumstance. Such sand as the finer grained beds of the millstone-grit are composed of, rests at an angle of about 34 degrees when thrown down on a slope in water so as to form the various stratula of drift-bedding, whereas, in the rocks themselves, that angle is now only about 24 degrees. At first sight this appears to throw some doubt on the accuracy of the explanation of the manner of its formation given above; but I have found by suitable experiments that when such sand was originally deposited, the spaces between the grains would amount to as much as 75 parts for each 100 of solid sand; whereas, now that the felspar sand has been decomposed and forced into the empty spaces, they amount to only 17 per cent. Therefore, the thickness of the rock must have been diminished in the proportion of 175 to 117, or to about two-thirds of the original; and thus the tangent of the angle at which the stratula of the drift-bedding are inclined to the true plane of horizontal stratification would be two-thirds of that of the original angle. If then, as already mentioned, this was 34 degrees, it would have been changed to about 24¼ degrees, which agrees so closely with what is actually the case, as to prove, in a most striking manner, the truth of the explanation I have offered.

I have made a very extensive series of observations of the direction of the currents present during the deposition of the millstone-grit, as indicated by the drift-bedding over a district twenty-five miles long in South Yorkshire and North Derbyshire, and I find that on an average the current was from the north-east. This also agrees with the direction in which the sandstone beds become thicker and of coarser grain; and altogether the fact of the materials having been drifted from the north-east, in my opinion, admits of no doubt whatever. If such be the case, the land whose waste supplied the material must be looked for in some such direction; and I now proceed to consider what kind of rocks it was composed of.

The only way in which this can be done is to examine the pebbles found in the grit-stone, which are as it were specimens of the rocks of that country preserved for our inspection. As previously remarked, by far the commonest pebbles are of quartz, like that forming one of the constituents of coarse-grained granites; but a considerable quantity are evidently portions of various yellow, pink, grey, and almost black quartz-rocks or quartz-schists. There are also many pebbles of white or brownish orthoclase felspar, similar to that in coarse-grained granites, and it therefore becomes interesting to ascertain for certain whether some of the quartz and this felspar did not originally constitute a granitic rock. After much careful search I have at length obtained extremely good proof of this fact, for I have found a few pebbles of undoubted granite, some of which are composed of a union of quartz and felspar, like a coarse-grained granite, which are in every respect similar to the quartz and felspar, so abundant as pebbles of each mineral alone. Besides such crystalline felspar there occur pebbles of a fine-grained felspathic rock, with a few laminæ of mica; and, though usually much decomposed, it appears to have been some kind of eurite. I have also found one pebble of a moderately fine and even-grained rock, much like some varieties of green stone, or a fine-grained syenite, consisting of a white felspar and of a dark coloured mineral, both too much decomposed to be accurately identified. It is also interesting on account of being the largest pebble I have yet found, for it is nearly four inches in circumference. With the exception of a single pebble of very fine-grained mica-schist, which some would call clay-slate, I have not found good examples of any other decided and well-marked rocks. Of course the absence of some kinds does not prove that they did not constitute part of the ancient land from which those just described were derived; for those which were soft or easily broken up would not be able to withstand the wearing action of drifting to a distance. This is probably the reason why so very few pebbles of micaceous rocks are found, although they usually form so large a portion of districts where such rocks as I have described occur; and the great amount of detached scales of mica in many of the associated finer grained beds makes this explanation still more satisfactory. Taking, then, all these facts into consideration, I think we are certainly led to the conclusion that the materials composing the millstone-grit in South Yorkshire, were, to a great extent, derived from the waste of land consisting of the so-called Primary rocks.

As I have already stated, there is most excellent evidence to prove that the current which drifted the materials into their present resting-place came from the north-east, and, therefore, we are led to expect that the ancient land which furnished them lay in some such direction. Casting our eyes toward that part of the compass, the first locality where any such rocks now occur, is the Scandinavian peninsula. Perhaps this is too far removed to have been the source of the tolerably angular, and certainly not much water-worn, pebbles sometimes found, but still it is a matter of considerable interest to compare the rocks of that country with the pebbles in our millstone-grit. The coarse-grained granite which gave rise to the pebbles of quartz and felspar must have been extremely like some specimens of the granite of Norway, in which the felspar and quartz are in large crystals, and are moderately clear and transparent; so similar, indeed, that the pebbles might have been portions of the self-same rock. On the contrary, the difference between them and any of the British granites I have hitherto examined is equally striking, for these are usually much too fine-grained, or, if the felspar be in large crystals, they are scattered about in a fine-grained base. It will, therefore, be seen that the character of the rocks and the direction from which they were drifted both point to a Scandinavian origin; and though the rocks in that part now constituting Norway and Sweden are probably too far removed, yet it appears to me that we must conclude that the materials of the millstone-grit in South Yorkshire were derived from the waste of a south-westward prolongation of an ancient Scandinavia, the site of which is now occupied by the North Sea.

ON THE FORMATION OF HAIL, ILLUSTRATED BY SOME LOCAL STORMS. BY THE REV. W. R. BOWDITCH, OF WAKEFIELD.

A heavy thunderstorm, which visited Wakefield, on Friday, July 13, 1855, appears worthy of record as affording a solution of certain phenomena which, I believe, have not hitherto been explained satisfactorily. I was overtaken by the storm when about two miles east of the town, and was compelled to seek refuge in some farm buildings. The morning had been fine but very hot, and when I left home at twelve o'clock there was no immediate appearance of a change. A few heavy premonitory drops of rain fell about ten minutes to one o'clock, and almost immediately the rain descended in torrents. After the lapse of a few minutes, thunder and lightning commenced, and flash followed flash in quick succession. During most of the storm the discharge took place so near that no perceptible interval elapsed between the flash and the report. Until my attention was wholly engrossed by the hail, I attempted to ascertain the time intervening between the flash and the report, but they were so nearly simultaneous that it was impossible to mark an interval. Each electric discharge was accompanied by a peculiar vibratory motion, which appeared to cause the shed in which I was sheltering to tremble and to emit a sharp ringing noise that does not admit of description, but which, when heard, cannot be forgotten. I never heard a similar noise during a storm but once, on which occasion great damage was done, and a woman was killed in her cellar about a hundred yards from the building in which I was when that storm took place. Upon both occasions the electric discharge caused the same vibratory motion, and the same sharp ringing noise, distinctly audible amid the thunder crash. This peculiar ring probably arises from motion amongst the materials of the building caused by the electric discharge, but *how* the motion is communicated is not easily explained.

With the fourth or fifth flash of lightning fell hailstones which averaged from half to three-quarters of an inch in diameter. These hailstones accompanied every flash which appeared to come from the zenith to the place where I was standing, but as soon as the storm had passed away so far that the interval between the flash and the report was appreciable, the hail either did not reach us, or but a very few hailstones fell mingled with heavy rain. *Between* the flashes *rain only* fell. *With the flash* came a volley of hailstones. Gradually a few drops of rain would mingle with the hail until at length rain only was falling. The transition from *rain to hail* was *sharp and well defined;* that from *hail* to *rain* as gradual as the change of "a dissolving view." The storm ceased at eighteen minutes past one o'clock, and so large a quantity of water had fallen that in the field adjoining the one in which I sheltered, potatoes were as flat as if a roller had passed over them, the surface of the ground between the ridges appeared to be puddled, and in some places the water stood several inches deep. Upon approaching the town it was apparent that the storm had assumed a widely different character at a very short distance. Four fields off my place of shelter, the corn was hardly injured. Three or four fields further, and potatoes showed no sign of anything more than an ordinary shower; and upon inquiry, I was informed by several intelligent persons that not one single hailstone had been seen, and that they had experienced nothing but ordinarily heavy rain, thunder, and lightning. I heard, however, that some hail fell at a place about half a mile to the N.E., but could not learn that it was particularly violent. The altered appearance of the clouds in the N.E., led me to think that the violence of the storm was spent in passing.

The hailstones which fell were of three kinds:—

1. Solid balls of ice having two or three small bubbles, or one larger one, containing air.
2. Balls of which from half to two-thirds were solid ice, the remainder being water and air enclosed in a crust of ice.
3. Balls formed by an outer crust of ice containing water[*] and air. In some instances this icy crust was so thin as to be broken by the fall, (though all I examined fell upon straw,) while in others it bore considerable pressure before it broke.

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[*] The fluid in these balls is called *water*, because I had no means of collecting the hail for analysis. Otherwise, no doubt, Nitric Acid, and, probably, other compounds might have been found.

In form, the hailstones were spheroidal, sensibly bulged at the equator, having depressions corresponding to the tropics, and the arctic and antarctic circles upon a terrestrial globe, and in some, if not all cases, slightly elevated at the poles. My attention was specially directed to the latter point, and, although in some cases the elevation of the poles was insufficient (if any) to warrant a judgment without measurement, in many, no doubt whatever could be entertained, for the polar portions were evidently tending to form points. It appeared as if the drop had been originally a perfect sphere, which, by rotation on its own axis, had become formed as found before congelation. The bulging towards the equator, and the elevation of the poles, appeared the complements of the depressions above described. The regular form of these bodies forbids the notion of gradual accretion in their descent, and puts beyond question the fact of their form being due to the action of a natural law upon fluid bodies placed in the same circumstances. It is to be hoped that other observations, or direct experiments, may enable us to ascertain whether this is the normal form of drops of water falling freely and rapidly through air, and afterwards solidified in a vacuum.

The phenomena of this storm seem to explain the formation of hail. Indeed I should not have thought it worthy of general notice, had it not tended to clear up the difficulties which appear to surround all attempts at giving a rational account of hail. The facts appear to me to teach the following theory of hail.

The clouds before a hail storm are highly charged with electricity of an opposite kind to that of the earth at the time, and the charge at length reaches such a tension that longer retention of it is impossible. These highly electrized clouds contain a superabundance of aqueous vapour, upheld by them in consequence of their electric condition. When the electric discharge takes place, it acts on the atmosphere precisely as a descending solid would do of an area equal to that occupied by the electric current. It drives before and to either side of it the particles of air, vapour, and whatever else is contained in the atmosphere, and owing to its enormous velocity, leaves its path a vacuum. The departure of the electricity from the storm cloud causes a simultaneous condensation of the vapour formerly upheld by electric influence, which now rushes down to the earth through the vacuum left below it. The velocity with which these drops of water descend may be almost inconceivably great. The form of the hailstones I have described, shews that while in a fluid state they had a rotatory motion around their own axes, in addition to the downward one due to electricity and gravity. This rotatory motion I conceive takes place at the earliest period of their descent towards the earth, during the time they are passing out of the cloud into the vacuum below it. In this double motion of enormous rapidity in a vacuum, we have the conditions of an evaporation quite adequate to the conversion of drops of water into hailstones. In this matter, however, we are not left altogether to inference. An account of what took place during a balloon ascent in France, seems to explain it. The Aeronaut left the earth, at Paris, June 18, 1786, Barometer 29, 68, Thermometer 84°. After descending once he again rose, and heard thunder beneath his feet. He then approached the earth a second time, but almost immediately rose to an elevation of 2,400 feet, Thermometer, 66°. He then descended for the third time, after which he left the earth at 8 p.m., and passed upward through a dense body of cloud, in which thunder followed lightning in quick succession, and the Thermometer fell to 21°; but when he had reached an elevation of 3,000 feet, and had passed beyond the region of electric disturbance, it regained its position of 66°. He remained in this region till 9.30 p.m., when the sun set. He was quickly enveloped in a thick mass of thunder clouds: the lightnings flashed on all sides, and the loud claps were incessant. The Thermometer again stood at 21°, and snow and sleet fell copiously. The storm lasted three hours. M. Testu says his balloon was affected by a sort of undulatory motion upwards and downwards, owing, he thought, to the electric action of the clouds. The lightning was excessively vivid; the thunder, sharp and loud, preceded by a sort of crackling noise. In this account we have a uniform initial temperature for the electric rain of 66° Fahrenheit, and a uniform temperature of 21° Fahrenheit in the electric region through which the drops descend to earth, and when these considerations are joined to the rapidity of their motion, evaporation alone is abundantly sufficient to account for their conversion into ice.

Were this an adequate explanation of what takes place, all the hailstones in a given storm should be alike, whereas they probably never are so, and in fact were not in the storm I have described. Other considerations therefore are required to account for the phenomena. What has been said would adequately explain hailstones of class I, or of class III, falling alone, but does not appear sufficient to account for their falling together, still less for those of class II, even if these only had fallen during the storm, and when the three descriptions fall together, the explanation is manifestly more insufficient. We must reconsider the effects rightly to apprehend their causes. Solid hailstones are obviously drops of water formed by an aggregation of atmospheric vapour, which has been subjected to an evaporation sufficient to abstract the heat of fluidity and allow of solidification. The same effect would result from a moderate evaporation, long continued, as in the case of freezing water by dried oatmeal under an exhausted receiver, or from a very rapid one continued for a short time, as when ether and solid carbonic acid are employed to abstract the heat of water. The time occupied by the descent of a hailstone being necessarily short, we are compelled to account for its perfect solidification by the rapid evaporation to which it has been subjected. It is obvious that hailstones of class II, must have been subjected to a different evaporating condition from those of the other classes, and it is from these I think we best learn the true explanation of the phenomena of hailstorms.

Were a solid body projected from the clouds to the earth, it would displace the atmosphere through the entire length of its path, causing a condensation on either side, and in front of it. Were its velocity equal to that of electricity, and its base a hundred miles square, there is no difficulty in conceiving such an amount of condensation on either side of its path as is adequate to the production of heat enough to cause light, its path from the cloud to the earth being a temporary vacuum which becomes filled from above as the solid descends.

The electric tension of a storm cloud continues to increase until it is able to overcome the resistance to discharge offered by the mass of air between itself and the earth. As soon as this degree of tension is reached, discharge takes place, and now no known force can resist the electric force, but its onward path must continue until equilibrium is restored by some body in an opposite electric condition. But, although ineffectually, the air offers resistance at every inch of the progress made by the electricity, and the condition of its progress is the overcoming of atmospheric resistance by a removal from its path of the opposing matter. Familiar illustrations of this are the fusion and dispersion in all directions of small metallic wires, stones, &c., which offer an obstacle to the passage of aerial electricity. We have thus a wall of condensed atmosphere on either side of the path taken by the electricity, while the path itself is a vacuum. The instantaneous condensation of probably many hundreds of millions of cubic feet of air, weighing hundreds of thousands of tons, evolves so much heat as to render the whole luminous, and we consequently have the flash of lightning composed merely of walls of light surrounding and corresponding in form with the path of the electricity.

Following the electricity down the vacuum is an enormous quantity of rain, the drops of which have acquired a rotatory motion around their own axes in addition to the downward one due to gravity and the electric attraction of the earth. Suppose them to descend with their axes of revolution horizontal. Then those in the centre removed from the influence of the surrounding heat will rapidly freeze and descend to the earth as solid balls of ice. Those with a pole pointing towards the source of heat, i.e., the air which condensation has rendered luminous, will be modified in character by that, and while the portion pointing inwards will be solidified, that pointing outwards will be merely encrusted, the influence of evaporation being partly counteracted by radiant heat and partly by the less perfect character of the vacuum. Those which chanced to descend with their equatorial portions brought successively under the influence of the heat, by having their axes of revolution parallel or nearly parallel to the condensed wall of atmosphere, will merely be encrusted equally on all sides, while if they chance to be so near that evaporation is compensated by radiation of heat from the luminous air, they will descend as rain, and, if nearer to the heat, they may even become vaporized and again ascend with the heated air to form portions of fresh clouds.

The observed phenomena indicate that the vacuum is filled principally, if not altogether, from above; but still it can hardly be doubted that some portion of the heated and condensed matter towards the limit of equilibrium between the two forces returns inward and is precipitated. I apprehend however that the chief part of this heated matter is carried rapidly upward, giving rise to the two winds (commonly a N. and S.) which mostly accompany thunder storms.

Instead of taking a straight path from the body which gives it off to that which receives it, and forming one unbroken flash of light, it is constantly throwing out branches on its path, owing to the force of the condensed atmosphere breaking in upon the current and causing a partial discharge in a lateral direction. These lateral sparks are always small, because, when the atmospheric force has acted upon and overcome the marginal electric force, it enters upon the path of the principal current, which is sufficient to overcome and drive back the intrusive atmosphere.

The intensely heated luminous matter which caused the flash of lightning instantly ascends into the colder regions, drawing after it two lateral currents. For a time this continues, and gives rise to the two winds which are commonly said to blow and meet during thunder storms. These lateral currents were well seen in a heavy hailstorm which did enormous damage in the neighbourhood of Badsworth, of which I wrote a description at the time that appeared in the *Times* and many other newspapers. Persons who were on opposite sides of the area of hail experienced torrents of rain, and asserted that lateral winds set in towards the centre of the storm and blew laterally with such violence that turnip plants were lifted more than an inch out of the ground. Three credible persons witnessed this in one field, and it is not possible to disbelieve their account. Others saw the boughs of the largest trees drawn upwards as by the embrace of a giant.

When the flash has passed, and the frigorific influence of a vacuum exists no longer, rain takes the place of hail, and continues until a repetition of the previous phenomena, when it becomes frozen and reaches the earth as hail.

Possibly also the upward currents established by the heating effects of the electricity may tend towards a precipitation of rain. The thunder clouds appear always to contain an abnormal quantity of water, owing to their strong electric charge. Supposing that charge to be positive, the upward current which meets the clouds will be strongly negative, and hence a restoration of electric equilibrium must take place upon their meeting. The result of this appears to be a copious rainfall, the size of the drops depending upon the rapidity with which equilibrium is established; or, in other words, upon the quantity of negative atmosphere from below which mingles with the positive clouds. Ultimately a colder current takes the place of that which has been set up, and according to common observation a north wind generally succeeds a thunder storm.

The cause I have indicated is sufficient to produce those more terrific results of electric action which ought rather to be called ice-storms than hailstorms, which do such enormous damage on the continent, and are not unknown in our own country. To this class belong the hail-plague of Egypt, (Exodus ix. 22—33); the storm which smote the Amorites, (Josh. x. 11); that which killed 6,000 of Edward Third's horses and 1,000 of his men near Paris, (Rapin. vol. i. 4, 31), or that which devastated Glocester and the neighbouring counties, in 1808, (Howard, Climate of London, ii. 50). Without analyzing the accounts of these and of many similar occurrences, it may suffice to take Howard's narrative, which he regarded as utterly inexplicable on received doctrines, and to show the applicability to it of the theory of hail, which I have now submitted. His account is this:—"Unlike the tempest of the milder zones, the thunder was remarked to roll in one continued roar for upwards of an hour and a half; during which time and long afterwards, the flashes of lightning followed each other in rapid and uninterrupted succession. But the most tremendous circumstance of this storm was the destructive *hail shower* which accompanied its progress. It may be doubted, however, whether such a name was applicable, for the masses of ice which fell bore no resemblance to hailstones, in magnitude or formation; most of them being of very irregular shape; broad, flat, and ragged; and many measuring from 3 to 9 inches in circumference.* They appeared like fragments of a vast plate of

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* The following note shews that the dimensions given by Howard are quite within the limits of experience:—

Dr. Halley describes two remarkable falls of hail which occurred in April and May, 1697. The latter was the most extraordinary. It occurred in Hertfordshire, after a storm of thunder and lightning. Several persons were killed by the hail, their bodies being beaten black and blue; vast oaks were split by it, and fields of rye cut down as with a scythe. The stones measured from ten to thirteen or fourteen inches in circumference. Their figures were various, some angular, some oval, some flat. (Philosophical Transactions, No. 229.) In the remarkable hail fall described by Dr. Neill, (Edin. Philos. Trans. vol. ix.) which occurred during a thunderstorm in the Orkneys, July 24, 1818, mingled with ordinary hail, were enormous masses of ice, some as large as the egg of a goose, whereby animals were killed, and several persons wounded. An enormous hailstone is recorded to have fallen, among other large masses, at Handsworth House, near Birmingham, during a thunderstorm in July, 1811. It consisted of a cuboidal mass, six and a half inches in diameter, and resembled a congeries of frozen balls, about the size of walnuts. (Traill's Physical Geography, p. 192.)

One of the most striking recent illustrations of hailstones capable of producing such effects as are here indicated, occurred in the summer of 1831, at Constantinople, and is thus described by Commodore Porter, at that time the American Envoy at the Porte:—"We had got, perhaps, a mile and a-half on our way (down the Bosphorus) when a cloud rising in the west gave indications of an approaching rain. In a few minutes we discovered something falling from the heavens with a heavy splash, and of a whitish appearance. I could not conceive what it was, but observing some gulls near, I supposed it to be them darting for fish; but soon after discovered that they were large balls of ice falling. Immediately we heard a sound like rumbling thunder, or ten thousand carriages rolling furiously over the pavement. The whole Bosphorus was in a foam, as though heaven's artillery had been discharged upon us and our frail machine. Our fate seemed inevitable; our umbrellas were raised to protect us, the lumps of ice

ice, broken into small masses in its descent towards the earth. The damage done by the storm was proportional to its intensity: buildings were struck, persons and cattle killed by the lightning, the windows and glass coverings of hothouses were demolished, the trees stripped of their leaves and fruit, and the crops reaped and thrashed by the hail." Howard's comment upon this is the following:—(Lectures on Meteorology, p. 129, 130,)—"But what shall we make of those larger hailstones consisting of an opaque nucleus thickly covered with clear ice, or of bullets of the latter, which, borne horizontally, and falling at a great distance from their source, break the windows, disbranch the trees, reap the crops, and kill the game of a whole district, leaving the ground thickly covered with ice; or of those yet more terrible masses, like round shot or fragments of stone, which have attacked armies, killing in a few minutes thousands of men and horses,—can these be the drops of rain merely frozen in the act of falling from the clouds? It is very probable, from circumstances, though it be beyond

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stripped them into ribands. We fortunately had a bullock's hide in the boat, under which we crawled and saved ourselves from further injury. One man of the three oarsmen had his hand literally smashed; another much injured in the shoulder; and all more or less injured. A smaller kaick accompanied with my two servants. They were both disabled, and are now in bed with their wounds; the kaick was terribly bruised. Balls of ice as large as my two fists fell into the boat; and some of them came with such violence as certainly to have broken an arm or leg, had they struck us on those parts. One of them struck the blade of an oar and split it. The scene lasted may be five minutes. . . . . I returned to the beautiful village of Buyukdere. The sun was out in all its splendour; at a distance all looked smiling and charming, but a nearer approach discovered roofs covered with workmen repairing the broken tiles, desolated vineyards, and shattered windows. Two boatmen were killed in the upper part of the village, and I have heard of broken bones in abundance. Many of the thick brick tiles with which my house is covered are smashed to atoms. Imagine to yourself the heavens suddenly frozen over and as suddenly broken to pieces in irregular masses of from half a pound to a pound weight, and precipitated to the earth. My own servants weighed several pieces of three quarters of a pound; and many were found by others of upwards of a pound. There were many which fell around the boat in which I was, that appeared to me to be as large as the swell of a large-sized water decanter."—Kitto, Note to Josh. x. 11.

our power to scrutinise the operation as in some other cases, that here is what the chemist calls a 'play of affinities' (?) in the elements of the higher atmosphere; vapour parting with its whole electric charge and becoming water, and this water instantly concreting into small grains of ice, (why?) which is quickly run together into large aggregates, in a manner which, though we may faintly conceive of the operation, we should in vain strive to imitate by any process we know. Those little opaque grains, like snow rolled up in pellets, which we see sprinkled on the ice in winter's mornings, having fallen in the night, are probably such concretes in the body of a cloud as by falling through a vaporous air in summer might collect ice enough upon them to make a regular hailstone. And we may admit the clear round balls, which do not, however, exceed a certain magnitude, to have been very large drops frozen aloft and increased by collecting ice from the air below. With respect to long icicles and pieces resembling fragments of a vast plate of ice formed aloft and then broken, we must here leave them among nature's wonders."

The only difficulty in this case appears to be in the quantity of water to be frozen, for of the adequacy of a vacuum to freeze it there can be little doubt. But is there any difficulty in conceiving the gathering aloft such a quantity of water as will suffice for the formation of this ice? At Geneva, October 25, 1822, there fell thirty inches of rain in a day, and at Joyeuse, October 9, 1827, thirty-one inches in twenty-two hours. This amounts to 1.4 inches an hour over the whole time, though beyond doubt the rainfall would be considerably in excess of this at times, and at other times much less. In London, two inches an hour have been observed during a thunder storm.*

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* The greatest storm which need be considered—such a storm as occurs in England only in the course of years—would be a fall of about two inches in the hour, or 44,789 gallons per acre.—*Minutes of Information on Sewerage, General Board of Health*, 1852, p. 60.

The whole aspect of the Glocester storm shows it to be extraordinary, and both the quantity of water and the continuance and perfection of the vacuum are explained by the statement that " the thunder was remarked to roll in one continued roar for upwards of an hour and a-half; during which time and long afterwards the flashes of lightning followed each other in rapid and uninterrupted succession." This coincides exactly with M. Testu's account: " the lightnings flashed on all sides, the loud claps were incessant, and the Thermometer fell to 21° Fahrenheit."*

There can be little doubt that electricity maintains aloft the enormous weight of water floating in the atmosphere as clouds, and that the quantity upheld is proportional to the electric tension. This latter may be inferred (when discharge takes place) from the character of the storm, and assuredly the Glocester ice-storm indicates an amount of electric tension which seldom happens in England. The volume of water descending at once appears, therefore, abundantly accounted for. The precipitation of this water in masses is an instantaneous consequence of electric discharge, and the rapidity with which the electric discharges followed each other in this instance accounts for cold enough to solidify any quantity of water which we can conceive to be precipitated.

I am able to add a few facts illustrative and corroborative of the views already advanced, and there is little doubt that a large body of similar observations may be made if the Members of the Society will bear the subject in mind. I shall be glad to receive accounts of similar occurrences, and to communicate them to the Society.

During the night of the 30th of June, 1856, a severe frost occurred in the neighbourhood of Wakefield, in places. A plot of early potatoes, belonging to myself, in vigorous growth, were severely cut by the frost right through the middle of the plot, in a direction east and west, while both sides of the piece were entirely untouched. The total breadth of the ground planted was not more than twenty yards, and it was situated in an open field of four acres. This frost I attribute to an electric discharge, and observation of the neighbourhood shews that it must have come from the east. Situated at Thornes, more than a mile to the south of my field, is a field on the side of a hill having a sharp declivity to the east. This field contained about three acres of potatoes, on the 30th June, which were cut down across their entire breadth, the sides being left as in my own case. Between the two fields is a valley containing many gardens occupied by the same crop, but in no one of them could I discover or hear of any injured potatoes. I subsequently inquired of a dealer in potatoes who has been for many years in the habit of buying the crop on the ground as it was growing, whether he ever knew part of a field to be injured by anything while the rest was untouched. He informed me that he had often known crops of early potatoes to be cut by the frost in places, while all the rest of a field was quite uninjured. Sometimes a corner of a plot was taken and the rest left; at other times a certain piece at the side, or in the middle, but in no case could he connect either injury or preservation with trees, hedgerows, or other causes, in fact, said he, "we can't account for it, we know nought about it."

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* Pouillet found that the temperature of hailstones varied from 31 degrees to 25 degrees.—*Muller's Physics*, p. 545. English Edition.

Another fact was communicated to me by an old man, a market gardener, who had been for many years in the habit of travelling by night with his produce from Wakefield to Bradford. He wished to explain to me the origin of the potato disease, and hence his account:—"One summer night, about seven years since, when the disease was so bad, I was going to Bradford, and when I got a few miles on the road all of a sudden it became so cold that it was fit to take the face off one. I never felt it colder at Christmas. When we had got about fifty yards, all on a sudden it was quite hot and sultry, and I can compare it to nothing but going in the depth of winter into a stove, (i.e., a hothouse). That heat, in my opinion, is the cause of the potato disease." Without entering upon the good man's theory of potato disease, here, I think, is clearly an electrical discharge producing winter's cold "fit to take the face off one" in the region of its action, and then, by the condensation of the atmosphere at the margin of the region of discharge, causing the free heat which is compared to that of a hot-house. The sudden production of the cold and its very limited extent shewn by the man's rapid emergence from it to intense heat, cannot, I think, be accounted for in any other way.

The absence of lightning (i.e., atmospheric matter heated to visibility) is no objection against this view, but rather a confirmation of it. Had the intensity of the electric discharge been greater, so that light was produced, the vapour present in the air must have been converted into ice by a more intense cold than was experienced, and hail or snow in the cold space would have resulted. But the fact of the cold being described as no more intense than that of an ordinary winter day (which need not in fact be near the freezing point, as, on a summer night, far less cold would appear relatively greater) requires the absence of light as part of the electric phenomena.

During a thunder storm which occurred on the 16th of June, 1858, about five p.m., in the neighbourhood of Mirfield, in Yorkshire, much damage was done by the hailstones which fell; many of these were of very large size, some were picked up after the storm which measured six and a half inches in circumference. In a brick-field at the Reformatory School, Hunger Hill, many of the bricks, which were newly made, exhibited the impressions in the soft clay caused by the hailstones; one of these bricks was burnt and sent to the Museum of the Philosophical and Literary Society of Leeds, in which is one hole two inches in diameter, by two and a half inches in depth.—HENRY DENNY.

ON THE BASALTIC FORMATION OF THE SOUTH STAFFORDSHIRE COAL FIELD. BY CHARLES TWAMLEY, ESQ., F.G.S., OF LONDON.

The South Staffordshire coal field consists of a long wedge-shaped mass of the carboniferous formation, lying immediately upon the Wenlock limestone and shale of the Silurian system, which has been thrust up through the permian and new red sandstone deposits. From its base, near Hales Owen, where it is about six miles wide, and which there gradually rises from underneath the permian and new red sandstone, it extends in a direction N.N.E. towards the town of Rugeley, a distance of about twenty-three miles, bounded on its two sides by two large faults, which converge towards each other until they meet near that town. These faults bring this wedge-shaped mass of Wenlock limestone and shales, and coal measures, into immediate and abrupt contact with the permian and new red sandstone, on its east and west sides; but this is somewhat interrupted on the eastern side, near Walsall, by the elevation to the surface of the Wenlock shale and limestone. The effect of the elevatory force which raised this great mass, was to bring the Wenlock shale and limestone, and the coal measures, which were previously covered with the permian and new red sandstone, estimated by Mr. Jukes to be about 3,000 feet thick, from its former low level to such a height that the Wenlock limestone, which lay at the bottom of all, now forms the highest land in the district, and the coal measures are on a level with the surface of the new red sandstone. Thus the whole of the Wenlock limestone and shales, and the superincumbent coal measures, have been altogether elevated at least 3,000 feet above their original position; the permian and new red sandstone measures, which covered the whole district, have been broken up and carried away by the denuding power of water, and their debris now form the large and extensive gravel beds which bound this coal field, more especially on its eastern side.

Now the means by which this vast mass of matter was thus elevated, could only have been by the intrusion underneath of a mass of matter in a state of fusion from igneous action, equal in bulk at least to that which was elevated, broken, and denuded from its upper portion: thus clearly showing that the present coal field was elevated by a mass of igneous matter, at least 3,000 feet thick, and which by subsequently cooling, preserved it in its present position. During the period of its being so elevated, it was broken and fractured, and the numerous faults which now exist throughout the district were made. Portions of this igneous matter forced a passage through some of these fractures, and becoming imbedded amongst the superincumbent strata, formed detached masses of igneous rock.

The largest mass of igneous matter which thus burnt through the Wenlock formation and the coal measures, became imbedded between the latter and the permian formation, and formed the line of basaltic hills which run in a south-easterly direction from the town of Dudley to the village of Rowley, for about two miles, and from one quarter to half a mile wide. This range, called the Rowley

Hills, is formed of a hard, compact, crystalline basalt, which is quarried in many places for road materials. It is, generally, in large irregular rhomboidal masses; but in a few places it has assumed the columnar form upon a small scale. Thus, at Fansley Hill, about three-quarters of a mile from Dudley, on the north side of a quarry of the usual hard, crystalline, massive basalt, a number of small columns, from three to four inches diameter, were found. They were not very fully displayed. At Barehills, a quarry about half a mile from the latter, nearer Rowley, some curved columns occurred, very similar to some at Powk Hill, near Walsall. The basalt was hard and crystalline, but the working has been discontinued for some time. The Birmingham Canal Company have lately made a tunnel underneath the range at this place, which is here about a quarter of a mile wide, and between sixty and seventy yards below the summit. Instead of meeting with a thick mass of hard basalt, they found nothing but damaged coal. Both these last-mentioned quarries are on the south side of the range.

On the other side, overlooking the village of Oldbury, is another instance of columnar basalt, at Pearl Hill quarry. The basalt here is of a totally different character, having lost its hard crystalline structure and become like dried clay—upon any attempt to remove any part, it tumbles to pieces. It is useless for road making, and the quarry is therefore abandoned.

Another body of intruded igneous rock occurs about eight miles north of this Rowley Range, which was discovered by Messrs. S. H. Blackwell, Sparrow, and Becket, a committee of the Dudley and Midland Geological Society (now unfortunately in a moribund state.) They traced it from about a mile east of the town of Wolverhampton to a mile west of Walsall, a distance of about six miles. It is imbedded in a lower part of the carboniferous series than the Rowley Range, is upon an average about two feet thick, and consists of a white felspathic igneous rock—of an earthy structure—hard when first extracted, but crumbles to pieces upon exposure to the atmosphere. For a mile or two from Wolverhampton it continues about the same thickness, and lies underneath a coal bed known in the district as the "Bottom Coal." It then breaks through this bed of coal and continues for a short distance lying immediately above it. It then swells out into a large knob or boss, throwing off one or two small veins into the superior strata, and causing two small faults therein. From thence in a westerly direction, with its usual thickness, until it reaches Powk Hill, where it has swelled out to a great thickness, and in cooling assumed the peculiar columnar forms we find there. In the course of their investigations, these gentlemen discovered that these beds of injected igneous rock were generally thicker at their edges than in the rest of their course. I think this may be accounted for in the following manner:—That portion of the igneous matter which was at the edge would have travelled farthest from the vent or fissure through which the whole mass was injected, and would, consequently, from having come in contact with a greater extent of strata of a lower temperature than itself, have cooled down below the rest of the mass.

Now, when the power which impelled the molten mass onwards ceased to act, a reaction would ensue, and, from the enormous pressure of the superincumbent strata, a portion of it would be forced back again; but the edges being cooled, and, therefore, partially consolidated, would retain their bulk undiminished.

Powk Hill is a portion of one of these edges, which, in cooling, has not only assumed the columnar form, but has also become a hard crystalline basalt. It rests upon a coal shale, very near the bottom of the carboniferous series in this part of the country. It was formerly thirty or forty feet higher. The top has been removed for mending; and the present interesting section will soon follow in the same direction.

The peculiarity of this quarry consists in the extreme divergence of the columns from each other, some being straight and vertical, whilst others are curved, and lie in a horizontal direction, and radiating from the tops of the vertical ones which are in the centre of the quarry; thus proving that the direction of such columns is not always perpendicular to the plane of cooling, as has been asserted to be the case.

I will only add that I believe the bed of felspathic trap, of which Powk Hill is the termination, is quite distinct from the Basaltic Hills of Rowley. The former bed, as previously stated, being embedded in the lowest members of the coal series in this district, whilst the Rowley Range lies above the thick or ten yard coal, which is among the highest.

Powk Hill was first mentioned, I believe, in Messrs. Coneybeare and Phillips's Geology of England and Wales, published in 1822, p. 459. It was afterwards more fully, but rather inaccurately, described by Mr. William Hawkes Smith, in an account of Birmingham and its vicinity, and it is mentioned in the memoir of the Geological Survey of J. Beete Jukes, Esq., published in 1853; but it is only recently that the beautiful and interesting section has been made which is represented in Photographs, (a series of which has been presented to the Leeds Philosophical and Literary Society), which my friend Mr. William Hawkes, of Birmingham, has been chiefly instrumental in procuring, and to whom I beg to give my thanks for his zeal and kindness in obtaining them.

STATISTICAL RETURNS OF THE MINERAL PRODUCE OF YORKSHIRE FOR THE YEAR 1857. BY ROBERT HUNT, ESQ., F.R.S., KEEPER OF THE MINING RECORDS.

Having recently completed my annual Statistical Report of the Mineral productions of the United Kingdom, I feel that it cannot be without interest to the meeting of the Geological and Polytechnic Society, to communicate the returns which have been obtained from Yorkshire. These will be found to be fairly complete, and to represent very accurately the present state of the Mineral Industries of that important county.

Lead.—The produce of the Lead Mines has been as follows :—

	Lead Ore.		Lead.	
	Tons.	Cwt.	Tons.	Cwt.
Braithwaite	91	17	65	0
Cononley	538	14	388	8
Grassington, including Yarnbury and Coalgrove Beck	1,449	10	1,049	4
Hebden Mines	275	2	182	2
Kettlewell, Conistone, and Buckden Districts	150	0	105	0
Wensleydale	2,550	0	1,643	0
Swaledale and Arkendale	6,326	0	3,722	0
Hurst	190	8	130	0
Scargill	60	0	44	10
The Pateley District	760	0	535	14
Teesdale Mines (in Yorkshire)...	14	10	10	16
	12,405	19	7,875	12

The produce of Lead Ore and Lead were, in 1856, respectively 12,174 tons 7 cwt. and 8,986 tons 2 cwt., showing an increase of 231 tons 12 cwt. on the Ore, and a decrease in the quantity of Lead produced to the extent of 1,110 tons

11 cwt., proving that the Ores raised were less metalliferous than in the previous year.

IRON.—The Iron Ore produce of Yorkshire is especially important. The remarkable district of the North Riding, which has formed the subject of Professor Phillips's lecture, yielded, in 1857, the following quantities of Ore:—

Eston Mines	562,473	Tons.
Hutton Mines	314,516	,,
Upleatham	171,366	,,
Staithes	29,910	,,
Swainby, near Stokeley	24,758	,,
Eskdale Mining Company	10,608	,,
Normanby Mines	159,898	,,
Skinnin Grove	5,548	,,
Hay's Mine	1,189	,,
Bird's Mine	18,990	,,
Birtley Mine	8,721	,,
Whitby Iron Company	9,418	,,
Rosedale Abbey Mines	7,500	,,
Raithwaite	6,132	,,
Sleight's Bridge	3,478	,,
Mirkside	10,000	,,
Rosedale Whike Staithes	15,979	,,
Rosedale, or Port Mulgrave	33,671	,,
Grosmont	20,000	,,
Total	1,414,155	Tons.

Those returns embrace the Iron Ores raised in the Cleveland district proper—the Esk valley and the coast north of Whitby.

The produce of these districts, in 1856, was 1,197,417 tons, showing an increase of 216,738 tons.

The distribution of these Ores along the lines embraced by the North Eastern Railway is interesting and important. For this and other Mineral returns I am especially indebted to Mr. Kitson, of Leeds, one of the directors, and to

Captain O'Brien, of York, the general manager of these extensive lines of railway.

				Tons.	Cwts.
From Whitby District—	Iron Ores	taken to	Middlesbro'	1,178	17
,,	Ditto	,,	Consett	6,399	11
,,	Ditto	,,	Whitby	59,043	6
,,	Ditto	,,	Masbro'	5,694	2
,,	Ditto	,,	Swinton	178	12
,,	Ditto	,,	Liversedge	371	5
,,	Ditto	,,	Elsecar	787	13
,,	Ditto	,,	Leeds	265	3
,,	Ditto	,,	Chapeltown	170	4
,,	Ditto	,,	Great Bridge	5	11
,,	Ditto	,,	Clay Cross	90	0
From Cleveland District, via Stockton	and Darlington Railway,	for	Washington	12,708	2
,,	Ditto	,,	Felling	41,543	0
,,	Ditto	,,	Wylam	11,412	14
,,	Ditto	,,	Birtley	6,654	11
,,	Ditto	,,	Darlington	11	10
,,	Ditto	,,	Norton	28,067	7
,,	Ditto	,,	Stockton	11,138	3
From Cleveland District, via North Yorkshire and Cleveland Railway,	Iron Ores	taken to	Stockton	12,118	17

Of the Argillaceous Iron Ores of the West Riding, it has not been possible to obtain an equally reliable return to the above. From the following collieries around Leeds, ironstone was procured:—White Horse Colliery, Rock Colliery, Alma Colliery, Rothwell Haigh Colliery, Potternewton Colliery, Farnley Colliery, Beeston Manor Colliery, Waterloo Main Colliery, Thorpe Hall Colliery, Cross Green Colliery, Osmondthorpe Colliery, Nevile Hill Colliery. From these collieries it has been estimated that 36,000 tons of Ore were produced in 1857. The total quantity of clay Iron Ore raised in the West Riding, as far as returns have been obtained, being 207,500 tons.

The following are the numbers of furnaces built, and which were in blast during the year in the Cleveland district :—

		Furnaces Built.	Furnaces in Blast.
1	Clay Lane	2	0
2	Cleveland	3	3
3	Eston	6	6
4	Middlesbro'	3	3
5	Ormsby	4	4
6	South Bank	3	3
7	Tees	5	4
8	Wreck Hill	2	0
9	Tees Side	2	0
10	Beckhole	2	0
		32	23

In the month of December seven of these furnaces were put out of blast, and during the year the furnaces at Wreck Hill, belonging to the Victoria Iron Company, were destroyed.

In the West Riding the furnaces built and in blast were as follows :—

		Furnaces Built.	Furnaces in Blast.
1	Beeston Manor	1	1
2	Bierley	4	3
3	Bowling	5	4
4	Chapeltown	2	0
5	Elsecar	5	4
6	Farnley	4	2
7	Holmes	2	2
8	Low Moor	5	3
9	Milton	2	2
10	Parkgate	1	1
11	Thorncliffe	3	2
12	Thorpe Hall	1	1
13	Worsbro' Dale	1	0
		36	25

The cold blast furnaces of the West Riding appear to have produced 63,000 tons of pig iron. The total produce of the West Riding is estimated at 117,000 tons; the North Riding, 179,838 tons. The total produce of pig iron in

Yorkshire being 296,838 tons. The produce in 1856 being 275,600 tons; showing an increase of 21,238 tons.

The exportation of pig iron from Middlesbro' for the last three years has been in 1855, 20,418 tons; 1856, 49,801 tons; 1857, 69,900 tons; and of wrought iron we sent to foreign countries, from the same port, in 1857, 44,594 tons.

Iron Pyrites.—(Coal brasses.)—An attempt has been made to determine the quantities of the iron pyrites of the coal measures which have been employed during the year in the manufacture of sulphuric acid and copperas (sulphate of iron) in the chemical works of the West Riding. From the neighbourhoods of Halifax, Todmorden, Huddersfield, &c., 3,560 tons were raised, the value of which was £1,572.

Coal.— The production of coals from the different districts of the West Riding of Yorkshire, from 374 collieries, has been 8,875,440 tons. In 1856, the coal production of the West Riding amounted to 9,083,625 tons, showing a falling off of 208,185 tons. The details of the production of this large quantity of fuel, which have been determined with much care, are as follows:—

DISTRICT.	No. of Collieries.	Coals raised.
Leeds	74	2,568,000 Tons
Bradford	48	976,500 ,,
Huddersfield	50	315,520 ,,
Barnsley	50	2,521,420 ,,
Halifax	30	410,000 ,,
Wakefield	36	740,000 ,,
Rotherham	18	458,500 ,,
Sheffield	26	490,000 ,,
Dewsbury	26	395,500 ,,
Penistone	4	
Pontefract	5	
Bingley, Settle, &c.	7	
Total	374	8,875,440 Tons

Of this quantity we find the

	Tons.	Cwts.	Tons.	Cwts.
North Eastern Railway carrying for consumption at places on the line, and for shipment at Hull and Selby			357,656	5
Midland Railway, for distribution at places on the line, and for delivery to other lines			310,168	0
The Great Northern for the following districts :—				
London to Hatfield	405,710	14		
Welwyn to Peterboro'	76,122	15		
Tollington to Arksey	137,199	2		
Peakirk to Lea	75,673	17		
East Lincolnshire line	36,395	10		
			731,101	18
			1,398,926	3

From the Yorkshire coal field, the following quantities were sent by sea to London:—In January, 4,719; February, 4,572; March, 2,972; April, 3,817; May, 2,896; June, 2,134; July, 3,023; August, 2,768; September, 2,598; October, 3,600; November, 6,100; December, 2,728; Total, 41,927 tons.

The quantities of coal sent by sea to various ports in the kingdom were—

	From Hull.	From Goole.	From Grimsby.
	Tons.	Tons.	Tons.
January	2,246	6,709	570
February	2,029	7,265	649
March	1,321	5,864	...
April	1,100	6,612	400
May	340	7,964	605
June	401	9,939	140
July	973	9,154	...
August	478	8,740	...
September	645	8,786	...
October	1,618	10,964	...
November	2,035	9,658	30
December	2,096	11,486	154
	15,282	103,141	2,548

The coals and coke exported from the following ports to foreign countries were as follows:—In the shipments from Grimsby are some Derbyshire coals, but the exact quantity cannot be ascertained, 40,000 tons were probably Yorkshire.

	HULL.		GRIMSBY.		GOOLE.	
	Coals. Tons.	Coke. Tons.	Coals. Tons.	Coke. Tons.	Coals. Tons.	Coke. Tons.
January	8,982	369	6,314	...	151	...
February	8,513	176	5,137	...	166	...
March	3,188	...	5,890	...	...	...
April	12,423	...	5,509	1	303	...
May	7,760	20	5,886	...	82	...
June	10,349	380	4,157	...	211	...
July	13,451	35	5,255	21	889	...
August	10,864	632	5,256	...	1,127	...
September ...	25,058	290	6,290	21	1,593	...
October	9,356	300	7,878	...	1,341	9
November......	15,946	470	6,691	...	1,496	...
December......	9,451	...	6,089	...	1,249	...
Total...........	135,341	2,672	70,352	43	8,608	9

By railway there were distributed 1,398,926 tons; by sea to London, 41,927 tons; by sea to other ports, 120,971 tons; by sea to foreign countries, (coal, 183,949 tons; coke estimated as coal, 5,448 tons) 189,397 tons.

The estimated value of the Lead Ore, £130,263; of Iron Ore, £810,827; of Iron Pyrites, £1,572; of Coals, £2,168,860. The estimated value of the raw mineral produce at the mine or the pit's mouth, £3,111,522.

In addition to these mineral returns, very complete replies have been obtained from 102 quarries in Yorkshire, producing building and paving stones, lime, grindstones, and whetstones. Through these I have been enabled to estimate the value of the stones raised in Yorkshire during 1857 as being £105,374. If we adopt the market value of the metals, and make this addition to the sum, the following will represent the amount added to our national wealth by the mining and metallurgical industries of Yorkshire:—

	£.
Lead.........	173,250
Pig Iron ...	1,013,142
Iron Pyrites	1,572
Coals	2,168,860
Stones	105,374
	£3,462,198

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